THE CONDITION AND TREND OF ASPEN COMMUNITIES ON BLM ADMINISTERED LANDS IN CENTRAL NEVADA - - WITH RECOMMENDATIONS FOR MANAGEMENT

Final

report

to

Battle Mountain Field Office
Bureau of Land Management
50 Bastian Road
Battle Mountain, NV 89820

by

Charles E. Kay, Ph.D. Wildlife Ecology
Wildlife Management Services
480 East 125 North
Providence, UT 84332
(435) 753-0715

February 2001

ACKNOWLEDGEMENTS

This research was funded by the Bureau of Land Management (BLM) under Work Order Number FGP000039 and I thank that agency for its support. BLM specialists Joe Ratliff, Soil Scientist, and Mike Stamm, Wildlife Biologist, were extremely helpful in selecting study sites and in providing documents germane to this study. I would also like to express my appreciation to Drs. Walt Mueggler and Dale Bartos for reviewing my work in central Nevada. Until his retirement, Dr. Mueggler headed the U.S. Forest Service's Aspen Ecology Project. Dr. Bartos was a member of that team and is now directing aspen research in southern Utah for the U.S. Forest Service. Dr. Bartos also made a site visit to Nevada at the beginning of this study. This report is part of a continuing 5 year aspen study (2000-2004) between the Battle Mountain and Elko BLM Districts funded through the 5900 Forest Health and Restoration Program. Joe Ratliff, Project Coordinator with the Battle Mountain Field Office, expresses his appreciation to Rick Tholin, 5900 Project Lead, for his valued support and assistance in making this project possible.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Aspen is of special concern in the West because the species does not commonly grow from seed due to its demanding seed-bed requirements. It is thought that environmental conditions have not been conducive to seedling growth and clonal establishment since shortly after the glaciers retreated 10,000 or more years ago. Hence, aspen clones found in central Nevada today have likely maintained their presence on those sites for thousands of years via vegetative regeneration; i.e. root sprouting. In addition, aspen communities support an array of other species and have the highest biodiversity of any upland forest type in the West. This is especially true in central Nevada where many aspen stands are associated with riparian communities. Aspen, though, has been declining in Nevada and throughout the Intermountain West since shortly after European settlement. The reasons for this have been attributed to climatic change, fire suppression, normal plant succession, wild ungulate browsing, and/or grazing by domestic livestock.

To test these hypotheses and to determine the status of aspen on BLM administered lands in central Nevada, I measured 126 representative aspen stands in the Shoshone, Simpson Park, Diamond, Toiyabe, Desatoya, and Roberts Mountains. I also measured all long-term aspen-containing exclosures in those mountain ranges. The exclosures were originally built to study the effect of livestock and/or wildlife use, but because the general climate is the same inside and outside the fenced plots, the exclosures can also be used to evaluate the climatic change hypothesis.

Many aspen stands in central Nevada have not produced new stems greater than 2 m (6 ft) tall in more than 100 years and many stands are in very poor condition. The status and trend of aspen communities in central Nevada, however, is not related to climatic variation, fire suppression, forest succession, or browsing by mule deer. Instead, the condition of individual aspen communities is related to past and present levels of livestock grazing. That is, aspen is declining throughout most of central Nevada due to repeated browsing of aspen suckers by cattle and/or domestic sheep - - repeated browsing eliminates sucker height growth, which prevents their growth into aspen saplings and trees. Without stem replacement, aspen clones are consigned to extinction.

This cause and effect relationship is most clearly demonstrated inside and outside exclosures. In all cases where it was protected, aspen successfully regenerated without fire or other disturbance and developed multi, stem-aged stands, while on adjacent, outside plots, aspen continued to decline. Aspen in central Nevada also experienced major regeneration events on allotments where livestock grazing was temporarily reduced or where BLM had mandated season of use changes. On some allotments, a change from season-long grazing to only early-season grazing, was enough in and of itself, without any reductions in animal unit months (AUMs), to allow aspen to successfully regenerate.

Thus, to reverse the decline of aspen in central Nevada it will be necessary to more closely manage livestock use. Depending on individual sites and the present condition of aspen, it may be necessary to fence some stands and/or restrict livestock to only early-season grazing. If aspen does not respond to those measures, however, it may be necessary to reduce AUM numbers on some allotments. It is also recommended that

BLM establish permanent monitoring plots in representative aspen communities throughout central Nevada to evaluate management decisions related to that species.

INTRODUCTION

Aspen (Populus tremuloides) is an excellent indicator of ecosystem health and ecological integrity in the western United States because the species does not commonly grow from seed due to its demanding seed-bed requirements (Perala 1990; West et al. 1994:10; White et al. 1998a, 1998b). In fact, there are no known instances of aspen clones having established from seed anywhere in the Intermountain West during the period of recorded history (Kay 1993). It is thought that environmental conditions have not been conducive to seedling growth and clonal establishment since shortly after the glaciers retreated 10,000 or more years ago (McDonough 1979, 1985; Perala 1990; Jelinski and Cheliak 1992; Mitton and Grant 1996). This means that aspen clones found in central Nevada today have likely maintained their presence on those sites for thousands of years via vegetative regeneration. Thus, aspen may be among the oldest living organisms on Earth and should be managed as old-growth, ancient forests, not a seral plant community (Grant 1993, Mitton and Grant 1996, Kay 1997a).

Aspen seedlings are more common in the northern Canadian Rockies (Peterson and Peterson 1992, 1995) and there may be "windows of opportunity" that allow seedling establishment at infrequent, 200 to 400 year or longer, intervals (Jelinski and Cheliak 1992:728), but successful sexual reproduction of aspen is still exceedingly rare (Mitton and Grant 1996). Aspen invariably occur as clones in which all the individual trees (ramets) are genetically identical, having grown from a common root system by vegetative shoots. If aspen is lost there are no known means of reestablishing those clones (Kay 1997a).

As a relatively short-lived tree (<150 years), long-lived aspen clones are often dependent on periodic disturbance such as fire to stimulate vegetative regeneration via root suckering, and to reduce conifer competition (Bartos and Mueggler 1979, 1981; Bartos et al. 1991, 1994; Shepperd 1993; Shepperd and Smith 1993). In the absence of fire, many aspen clones in the Intermountain West may be replaced by more shade-tolerant species, although climax aspen is common (Mueggler 1988). Aspen, however, will burn only when it is leafless and when the understory plants are dry enough to carry a fire, conditions that occur only early in the spring before understory regrowth, and late in the autumn after leaf-fall and the understory plants have cured (Fechner and Barrows 1976, Brown and Simmerman 1986, DeByle et al. 1987). During both those periods, though, there are few lightning strikes and virtually no lightning-started fires in the West (Kay 1997a, 2000). This would suggest that in pre-Columbian times, native burning may have been more important than lightning-started fires in maintaining aspen and other plant communities (Kay 1997a, 1997b, 1997c, 2000).

In addition, aspen communities support an array of other species and have extremely high biological diversity (DeByle and Winokur 1985, Peterson and Peterson 1992, Stelfox 1995). In fact, aspen has the highest biodiversity of any upland forest type in the West (Finch and Ruggiero 1993). Bird communities, for instance, vary with the size, age, and location of aspen clones, as well as with grazing intensity and history (Young 1973, 1977; Balda 1975; Flack 1976, Page et al. 1978; Winternitz 1980; Casey and Hein 1983; Oakleaf et al. 1983; Taylor 1986; Putman et al. 1989; Daily et al. 1993; Ehrlich and Daily 1993; Johns 1993; Westworth and Telfer 1993; Stelfox 1995; Grant and Berkey 1999). So if aspen is lost, many birds and small mammals will decline; some precipitously (Ehrlich and Daily 1993). This is especially true on BLM lands in central Nevada where many aspen communities are found in riparian settings (Schenbeck and Dahlem 1977, Kennedy et al. 2000).

Moreover, aspen provides highly palatable forage for elk (Cervus elaphus), mule deer (Odocoileus hemionous), and livestock throughout the West (Wallmo and Regelin 1981, Nelson and Leege 1982, Endersby 1999). Aspen, however, is sensitive to repeated browsing and range use levels. High-density elk populations commonly strip bark from mature aspen and severely browse aspen suckers that can prevent stand regeneration and which may eventually lead to the loss of aspen clones (Krebill 1972; Olmsted 1977, 1979, 1997; Weinstein 1979; Kay 1985, 1990, 2001a, 2001b; Shepperd and Fairweather 1994; Baker et al. 1997; White et al. 1998a, 1998b; Ripple and Larson 2000; White 2001). Large numbers of mule deer can also prevent aspen regeneration (Olmstead 1979, Kay and Bartos 2000), and if not properly managed, livestock can have similar negative impacts on aspen communities (Baker 1918, 1925; Sampson 1919; Coles 1965; Weatherill and Keith 1969).

Recent evidence indicates that aspen has been declining throughout the Intermountain West since shortly after European settlement (Schier 1975; Schier and Campbell 1980; Kay 1997a, 1997b). Since 1962, the acreage of aspen dominated forests in Arizona and New Mexico has decreased by nearly 50% (U.S. Forest Service 1993, Cartwright and Burns 1994, Johnson 1994). While in the northern Rockies, aspen has declined by up to 90% since the late 1800s (Kay 1990, 1997a, 1997c; Kay and Wagner 1994, 1996; Kay et al. 1999). On Idaho's Targhee National Forest, inventory data show that 36% of the West Camas Creek drainage was dominated by aspen in 1914, but today, aspen occupies only 4% of the area - - figures that are confirmed by repeat-photographs (Kay 1997a). In Utah, aspen has also declined from its historical distribution (Bartos and Campbell 1998). On Utah's Dixie National Forest, for instance, there were historically over 590,000 A. of aspen while today there are only approximately 200,000 A. Furthermore, many aspen stands contain old-age or single-age trees and have not successfully regenerated for 80 years or longer (Mueggler 1989a, 1989b). It has also been observed that aspen has failed to regenerate and is declining on BLM lands in central Nevada (Schenbeck and Dahlem 1977).

At least four hypotheses have been advanced to explain the decline of aspen throughout the Intermountain West (Kay and Bartos 2000). (1) Climatic change - - the climate was more favorable for aspen in the past and today's drier climate precludes aspen regeneration (Despain et al. 1986, Romme et al. 1995, Baker et al. 1997). (2)

Conifer invasion and fire suppression - - aspen is a seral species that will not successfully regenerate unless the overstory aspen and invading conifers are killed by fire (Houston 1973, 1982; Loope and Gruell 1973; Gruell and Loope 1974; Despain et al. 1986), and thus, modern fire suppression and forest succession have adversely effected aspen. (3) Livestock grazing is preventing the growth of aspen suckers into trees (Sampson 1919, Baker 1925). And (4) repeated browsing by mule deer and/or elk is preventing aspen sucker height growth and the successful regeneration of aspen stands (Coles 1965; Bartos and Mueggler 1979, 1981).

To test these hypotheses and to determine the status of aspen on BLM lands, I measured the condition and trend of aspen communities throughout central Nevada within the Battle Mountain District (Figure 1). I also measured all long-term aspen-containing exclosures in the Shoshone, Simpson Park, Diamond, Toiyabe, Desatoya, and Roberts Mountains. These exclosures were originally built to study the effect of livestock and/or wildlife use (Tueller 1979, Tueller and Monroe 1980), but because the general climate is the same inside and outside the fenced plots, they can also be used to test the climatic change hypothesis (Laycock 1975). The Shoshone, Simpson Park, Diamond, Toiyabe, Desatoya, and Roberts Mountains were selected for study by the Bureau of Land Management because aspen stands in those areas are thought to be representative of conditions in the Battle Mountain District.

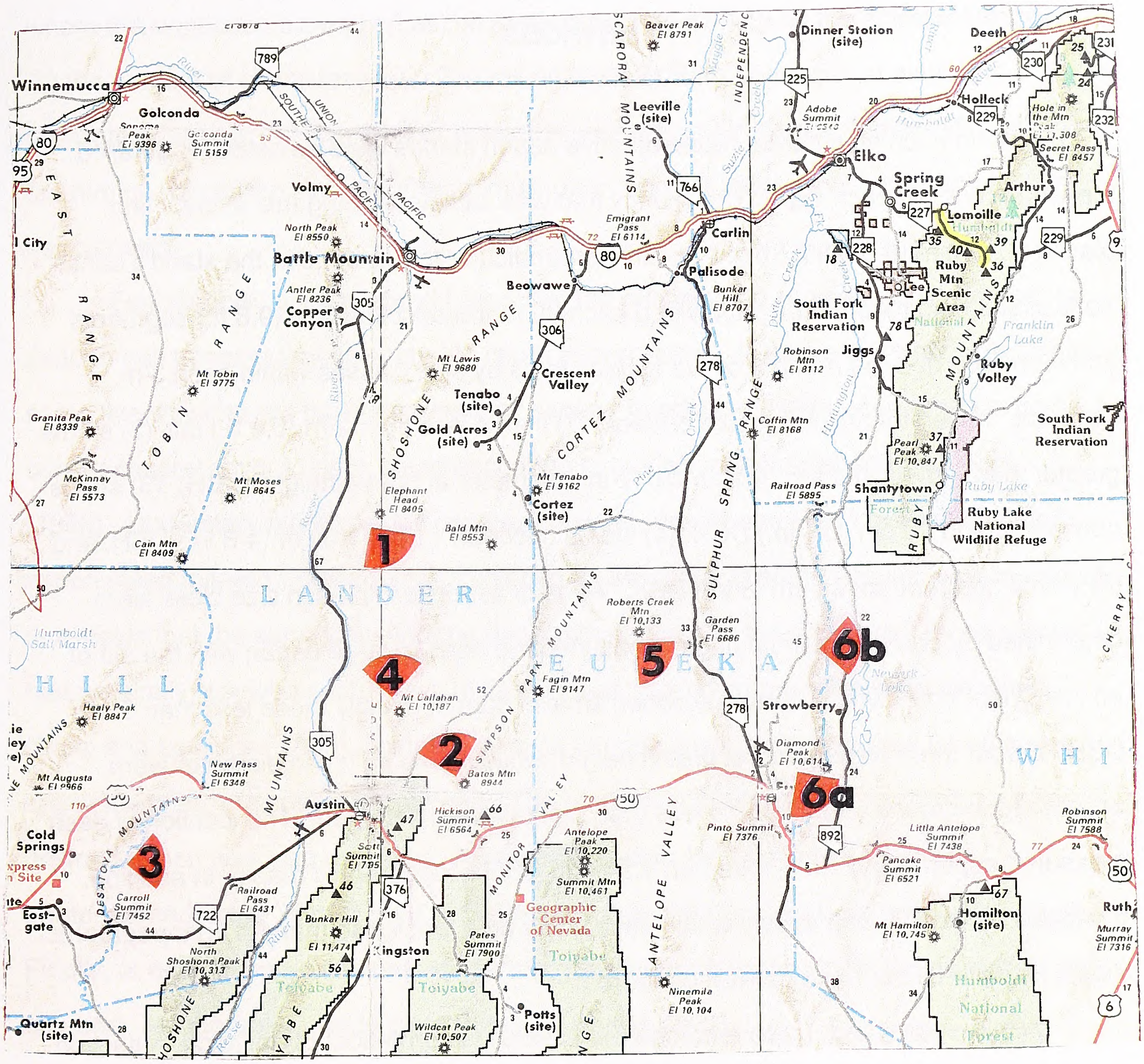

Figure 1. General location of aspen study sites in central Nevada. 1 - - Shoshone Mountains; 2 - - Simpson Park Mountains; 3 - - Desatoya Mountains; 4 - - Toiyabe Mountains; 5- - Roberts Mountains; 6a - - south Diamond Mountains; and 6b - - north Diamond Mountains.

METHODS

Within each study area, representative aspen stands were selected for detailed measurement. At each aspen community that was sampled during this study, I first placed a 2x30 m (6.6x98 ft.) belt transect perpendicular to the slope in the stand's center. To facilitate data recording, I subdivided each 30 m transect into 3 m (9.8 ft.) segments and then recorded the number of live aspen stems by size classes within each 3 m segment. I used the following size classes: (1) stems less than 2 m (6.6 ft.) tall, (2) stems greater than 2 m tall but less than 5 cm (2 in.) diameter at breast height (DBH), (3) stems between 6 and 10 cm (2-4 in.) DBH, (4) stems between 11 and 20 cm (4-8 in.) DBH, and (5) stems greater than 21 cm (8 in.) DBH. Ages of aspen within each size class were determined by counting annual rings. I obtained the ages of large aspen with the aid of an increment borer while I cross-sectioned smaller stems, usually those less than 5 cm DBH. Larger trees were cored at breast height, while stems <5 cm in diameter were usually cut at ground level. Stems less than 2 m tall were not aged. The location of each measured aspen stand was plotted on 1:24,000 USGS topographic maps. In addition, the locations of all aspen stands within each study area were also marked on topographic maps, as were all the routes driven or walked.

Within each stand, I also recorded the following information: (1) location - - section, township, and range; (2) elevation as determined from topographic maps; (3) Universal Transverse Mercator (UTM) grid coordinates, again estimated from topographic maps; (4) aspect -- north, northeast, east, southeast, south, southwest, west, and northwest; (5) estimated slope in percent; (6) estimated stand size; (7) an estimate of the mean percent of each stem that had been damaged by ungulate bark stripping - - of the animals commonly found in Nevada, bark stripping is only done by elk, not deer or livestock (Krebill 1972); (8) if the stand had newly regenerated stems greater than 2 m tall but less than 5 cm DBH, an estimate of the percent that showed evidence of ungulate highlining --

where the ungulates browse off all the lower branches as high as the animals can reach; (9) the percent of stems less than 2 m tall on each 2x30 m transect that exhibited ungulate browsing; (10) whether or not water was present in or near the stand; and (11) the number of cattle, domestic sheep, mule deer, and elk pellet groups on each 2x30 m belt transect.

Furthermore, at each stand I recorded the number and species of conifers on the 2x30 m belt transect that was used to count aspen stems. Conifers were recorded by the same five size classes that were used for aspen. In addition, I estimated the total percent conifer canopy cover in each stand according to guidelines established by Mueggler (1988). Understory plant species composition was visually estimated in each sampled aspen stand following procedures developed by Mueggler (1988). Shrubs were identified to species, but the same could not be done with grasses or forbs because those plants had generally received such heavy utilization that they could not reliably be identified (Clary and Leininger 2000). Instead, percent canopy cover was estimated for all grass species and all forb species combined. The proportion of bare soil, rock, litter, and downed aspen was also recorded. All aspen selected for detailed study were photographed using 35 mm color slide film to document stand and understory conditions. Finally, at each aspen-containing exclosure, data were collected on inside, as well as on adjacent, comparable outside plots (Kay and Bartos 2000).

BLM provided information on the grazing history of each aspen study area. Unfortunately, the agency's files are incomplete and seldom contain data on actual livestock use. Instead, BLM generally has information on AUM (Animal Unit Month) allocations, as well as the number of AUM's each permittee paid to activate in any one year, called grazing bills. Grazing bills, however, may not reflect actual use as many ranches simply pay for all the AUM's they are allocated each year to maintain their grazing permits. At the end of each grazing season, ranchers are required to submit actual use reports, but those too are only estimates (Duane Crimmins, BLM biologist, personal communication, Dec. 2000). Hence, based on the information in BLM's files, it is only possible to document general grazing trends on each allotment. BLM, for instance, does have records on legally mandated changes in AUM allocations. That is to say, has the ranchers' basic AUM authorizations been increased or decreased? BLM also has data on any season of use changes that have been implemented by the agency. Again, however, actual use data is lacking because there simply are not enough agency personnel to field check each and every action of its grazing permittees.

RESULTS AND SITE ANALYSES

In all, 126 representative aspen stands were measured in the Shoshone, Simpson Park, Diamond, Toiyabe, Desatoya, and Roberts Mountains. The stands were numbered consecutively from NV-1 to NV-126 as they were measured in the field. Appendix A contains the 1:24,000 project maps, while copies of the original data sheets are located in Appendix B. Appendix C contains 1,038 - - 35 mm color slides of project aspen stands. No elk sign was observed during this study and no instances of ungulate bark stripping were recorded, so those data were omitted from the summary tables for each study area. Conifers were generally absent from all aspen stands, so those data were also omitted from the tabular summaries, but may be found on the original data sheets (Appendix B).

Shoshone Mountains

The aspen study area in the Shoshone Mountains (Appendix C - - slides 1-120) was situated at the head of Cottonwood Creek in a basin known locally as Elephant Head (see maps Appendix A). This location contains several springs in an otherwise dry environment and is heavily used by cattle (Figure 2). Aspen is limited to only a handful of stands and all clones exhibited evidence of marked decline (Figures 3 and 4). As most clones contained only a few mature trees, I counted all live stems >2 m tall in each stand instead of using 2x30 m belt transects (Table 1). Except where protected, all aspen suckers showed repeated evidence of ungulate browsing (Figure 5), primarily by cattle, as little mule deer or wild horse sign was observed in any aspen stand. Only where protected inside exclosures (Figures 6 and 7) or by fallen trees (Figure 8; Ripple and Larsen 2001) have aspen been able to escape browsing and reach heights >2 m tall during the last 50 years.

Although the area occupied by live aspen has declined markedly within most stands (Figures 3 and 4), mature trees and protected stems exhibited excellent diameter and height growth (Table 2). Where live trees existed, all stands produced abundant aspen suckers, but again, except where protected, all suckers showed evidence of repeated browsing (Table 1, Figure 5). Within all aspen stands, grasses and forbs had been utilized to ground level, or below, by cattle (Clary and Leininger 2000). Bare soil was the largest understory canopy class in all stands and averaged 60% (Table 3), except in stand NV-9a (20%), which received less cattle use due to rock outcrops and an exceedingly steep slope (Table 1).

Table 1. Aspen stand parameters in the Shoshone Mountains.

	Stand Number										
	NV-1	NV-2	NV-3	NV-4	NV-5	NV-6	NV-7	NV-8	NV-9a	NV-9b	NV-10
Elevation (ft)	7040	6950	7300	7400	7600	7560	7400	7500	7500	7450	6680
Aspect	NW	NW	NE	NE	N	NE	NE	E	E	E	N
Slope (%)	5-20	5-10	30-40	20-50	5	5-30	5-40	20-100	100	40	10-30
Stand size (m)	30x160	20x80	80x80	30x80	8x8	40x80	150x200	50x200	50x200	50x200	30x50
Regeneration highlined (%)	100	100	100	100	100	NA	100	100	50	NA	100
Suckers browsed (%)											
current year	100	100	100	100	100	100	100	100	82	100	100
past years	100	100	100	100	100	100	100	100	70	100	100
Aspen stems per stand											
2m < < 5cm DBH*	5	2	5	65	60	6	3	45	**	**	45
6-10 cm DBH*	4	-	10	45	26	5	2	15	**	**	3
11-20 cm DBH*	5	2	10	40	-	-	3	9	**	**	5
>21 cm DBH	32	9	9	19	3	12	16	42	**	**	4
Water in/near stand	Yes	Yes	Yes	No	No	Yes	Yes	No	No	No	Yes

*Stems protected by fallen trees, steep cliffs, or inside fenced plots - - no other aspen have successfully grown >2 m due to repeated browsing by cattle.
**See text - - complete stem counts were not done.
NA=Not applicable; see text.

Table 2. Age and diameter of aspen in the Shoshone Mountains.

Stand Number	Stem Diameter (cm)/Age (yrs.)
NV-1	28/45, 26/42, 45/R*, 48/R
NV-2	40/62, 44/65
NV-3	18/18, 20/22, 44/68
NV-4	9/16, 15/28, 28/48, 32/50
NV-5	8/12, 10/12
NV-6	50/105
NV-7	35/62
NV-8	7/14, 13/31, 25/43, 26/45
NV-9a	3/7, 3/7, 5/12, 6/12, 15/43, 18/52
NV-9b	14/32, 19/55
NV-10	10/13, 12/14, 45/76

*Stem with heart rot that could not be aged.

Table 3. Understory species composition of aspen stands in the shoshone Mountains. T=trace.

	Stand Number and Percent Canopy Cover										
Species	NV-1	NV-2	NV-3	NV-4	NV-5	NV-6	NV-7	NV-8	NV-9a	NV-9b	NV-10
Big sagebrush	30	25	20	10	T	20	25	20	T	T	25
Currant	T	T	T	T	T	T	T	T	T	5	T
Rose	-	T	-	-	-	-	-	-	-	-	10
Serviceberry	-	-	T	T	T	-	-	-	T	-	T
Chokecherry	-	-	-	-	-	-	-	5	30	10	-
Grasses	5	5	-	T	5	10	5	T	T	T	5
Forbs	5	5	20	T	5	15	5	T	T	T	5
Bare soil	50	60	50	80	80	50	60	65	20	70	50
Litter	-	-	-	-	-	-	-	-	-	-	-
Rock	-	-	-	-	10	-	-	-	50	15	-
Downed aspen	10	5	10	10	-	5	5	10	T	T	5

Figure 2. A typical riparian community in Cottonwood Basin. All riparian areas have been heavily impacted by livestock. Note the bare dirt, eroded soil, and general absence of vegetation. Print from color slide (Appendix C - - No. 59) by Charles E. Kay; August 18, 2000.

Figure 3. Aspen stand NV-1 in Cottonwood Basin. Dead aspen trees have not been replaced with new stems because all aspen suckers have been repeatedly browsed. Downed aspen mark the original extent of the stand. That is to say, this and other aspen stands in the area were once much larger and have declined over the years due to excessive herbivory and an absence of regeneration. This is also a riparian area with flowing water. Print from color slide (Appendix C - - No. 11) by Charles E. Kay; August 18, 2000.

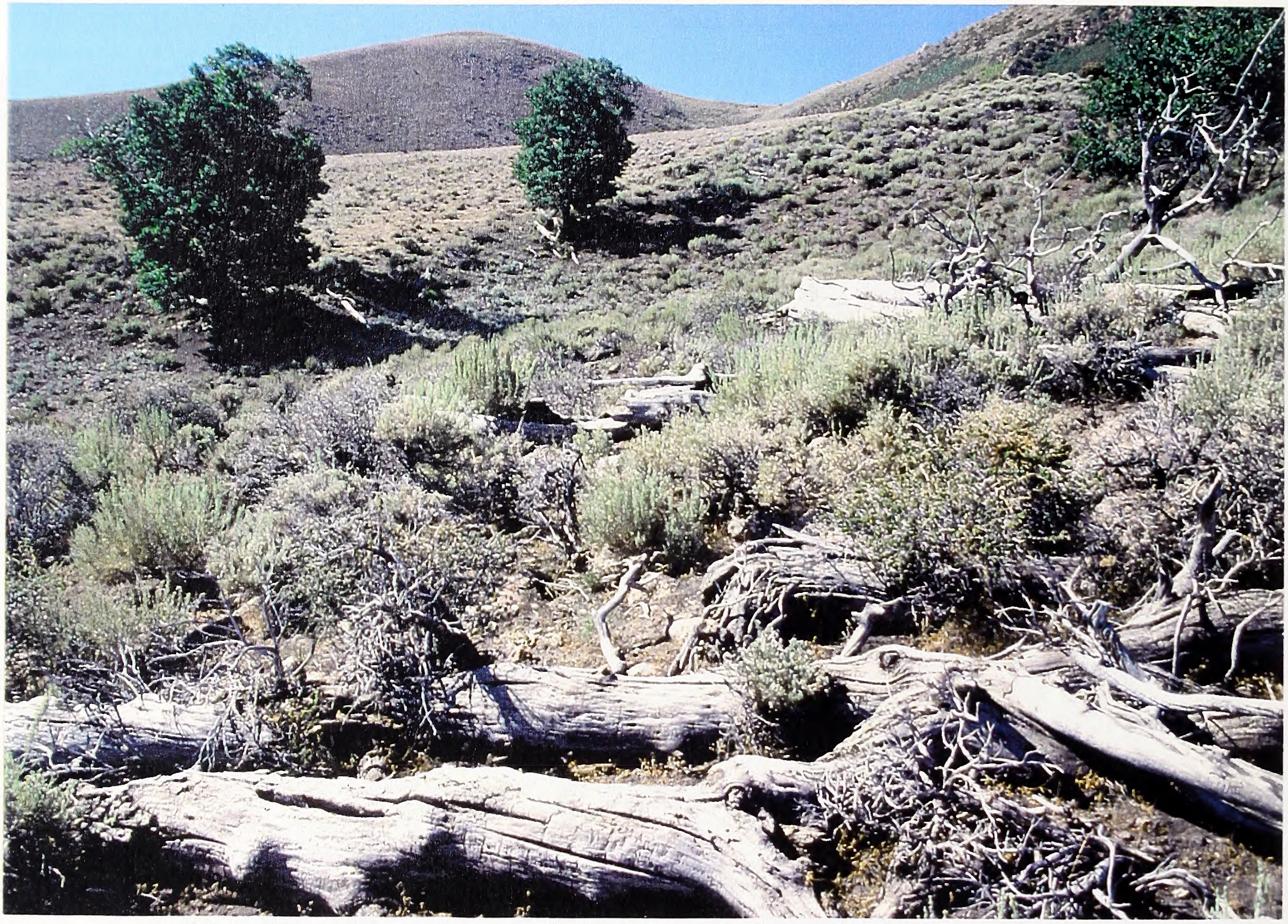

Figure 4. Aspen stand NV-7 in Cottonwood Basin. Dead aspen trees have not been replaced with new stems because all aspen suckers have been repeatedly browsed. Downed aspen mark the original extent of the stand. That is to say, this and other aspen stands in the area were once much larger and have declined over the years due to excessive herbivory and an absence of regeneration. Print from color slide (Appendix C - - No. 91) by Charles E. Kay; August 19, 2000.

Figure 5. A typical aspen sucker (NV-4) in Cottonwood Basin. Except where protected by fencing or fallen trees, aspen suckers in Cottonwood Basin all exhibited signs of repeated browsing. Red and white survey pole in one foot increments for scale. Print from color slide (Appendix C - - No. 52) by Charles E. Kay; August 18, 2000.

Figure 6. Aspen (NV-5) protected from grazing inside a small fenced plot in Cottonwood Basin. The larger Cottonwood Basin Exclosure (BLM 4696) fence is on the right next to which a small area has been fenced to exclude livestock. Regenerated aspen saplings had a density of 5,138/A and were 12 years old. Cattle have recently breached the small exclosure and highlined all the new aspen saplings. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 62) by Charles E. Kay; August 18, 2000.

Figure 7. Aspen regeneration inside a small fenced plot (NV-6) within the larger Cottonwood Basin Exclosure. The larger exclosure fence has been repeatedly cut by unknown parties and aspen has not regenerated due to repeated browsing by livestock. Within the smaller fenced plot where cattle do not have access, however, aspen has regenerated at 6,800 suckers/A and 7,500 saplings/A. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 74) by Charles E. Kay; August 19, 2000.

As judged by the presence of downed aspen (Figure 3), stand NV-1 once occupied an area of 52,500 ft^2, but now contains only 32 stems >2 m tall (Table 1). All aspen suckers were repeatedly browsed, and only aspen stems protected by fallen trees successfully regenerated in recent years. In those instances, as mature aspen died and fell, they jack-strawed in such a manner as to protect emergent suckers from ungulate use. In essence, the interlocking fallen trees produced a de facto exclosure where ungulates, in this case cattle, could not physically reach the aspen suckers (Figure 8). This is similar to what Ripple and Larsen (2001) reported in Yellowstone National Park where fire-killed conifers fell and protected aspen from excessive use by elk. This is an indication that ungulate browsing, not other factors, is responsible for aspen's observed decline.

NV-2 is located approximately 500 ft below NV-1. Although NV-2 once occupied more than 17,000 ft^2, it now contains only nine aspen stems >2 m tall. NV-1 and NV-2 are both situated along a small stream (Figure 3), and trees in both stands have wide growth rings indicative of excellent growth. NV-3 is also located along a stream and presently contains only nine live aspen >21 cm DBH - - all other stems >2 m tall (Table 1) owe their existence to the interlocking branches of fallen aspen. NV-4 is not near flowing water, and instead is situated on a steep site with noticeable soil creep and fallen aspen, which has allowed a number of stems to escape browsing. The eastern edge of NV-4 has been consumed by a soil slump (Appendix C - - slides 49-50).

Aspen stand NV-5 is situated inside a small (27x27 ft) fenced plot (Figure 6), which contained 60 aspen suckers, 60 aspen 2 m < but <5 cm DBH, 26 stems 6-10 cm DBH, and 3 aspen >21 cm DBH. This is equal to a sucker density of 3,585 stems/A,

Figure 8. Regenerated aspen stems protected from grazing by fallen trees in stand NV-3. As mature aspen have died and fallen, they jack-strawed in a manner that shielded emergent aspen suckers from browsing. That is to say, the interlocking fallen trees produced a de facto exclosure that prevented physical access by livestock. This has happened to one degree or another in most aspen stands in Cottonwood Basin and is an indication that ungulate browsing, not other factors, is responsible for the observed decline in aspen, as well as the failure of those stands to produce an abundance of new stems >2 m tall. Print from color slide (Appendix C - - No. 39) by Charles E. Kay; August 18, 2000.

and a regenerated sapling density of 5,138/A. Based on the age of the recently regenerated aspen, this area was fenced to exclude livestock 12 years ago. The fence has since fallen into disrepair, and when measured, all aspen suckers showed signs of repeated browsing, and all the stems >2 m tall had been highlined by cattle. From the dense, robust growth inside the exclosure, though, it is apparent that climate is not limiting aspen on this site.

NV-6 is located inside the Cottonwood Basin Exclosure (BLM 4696). This larger exclosure was built a number of years ago but the fence has been repeatedly cut by unknown parties such that cattle have had continual access to the inside area. Not surprisingly, aspen has not been able to produce new stems >2 m tall despite sucker densities of more than 6,700/A (Appendix B), for all suckers showed evidence of repeated browsing (Table 1). Interestingly, however, someone fenced a small area (8x8 ft) within the larger exclosure, and inside that fenced area, aspen sucker density was 6,800/A, while aspen sapling density was nearly 7,500/A (Figure 7) - - again indicative of excellent growing conditions in the absence of livestock. The 12 live, mature aspen trees were all more than 100 years old (Table 2).

NV-7 is located immediately west of the Cottonwood Basin Exclosure. This stand once occupied an area of over 30,000 ft^2, but now contains only 16 live, mature aspen (Figure 4). Eight other stems were >2 m tall, but all were protected by downed woody debris (Ripple and Larsen 2001). NV-8 is uphill from NV-7, and NV-8 contained several recently regenerated stems >2 m tall, but only where aspen was protected by fallen trees. Suckers on one 2x30 m belt transect (Appendix B) had a density of over

8,700 stems/A, but all showed evidence of repeated browsing.

Stand NV-9 is located to the north of NV-8 (Appendix A). The upper part of the stand (NV-9a) is located on a steep slope with numerous rocky outcroppings, which limits use by cattle, while the lower part of the stand (NV-9b) has a more gentle slope and lacks rocky outcroppings, which allows more access by livestock (Holechek 1988). Single 2x30 m belt transects were placed in both NV-9a and NV-9b, and those data indicate that aspen successfully regenerated only in the more inaccessible part of the stand.

Aspen Stem Densities/A

Size class	NV-9a	NV-9b
<2 m	2,295	3,240
2 m < < 5 cm DBH	2,025	0
6-10 cm DBH	810	0
11-20 cm DBH	378	202
>21 cm DBH	0	0

NV-10 is situated around a spring near the lower part of the road into Cottonwood Basin (Appendix A). Only four mature aspen were alive in this stand, although 53 other stems had recently grown >2m tall where protected by fallen aspen (Ripple and Larsen 2001). All aspen suckers, though, showed evidence of repeated browsing.

Simpson Park Mountains

Twenty-nine aspen stands were measured on Bates Mountain (NV-11 to NV-39, Appendix C - - slides 121-334) in the North Fork of Stiner Creek, South Fork of Stiner Creek, and Water Canyon Drainages (Appendix A). Aspen was also evaluated along the lower portion of Stiner Creek, including the fenced, riparian pasture at the mouth of the canyon. The majority of aspen stands on Bates Mountain are in the Grass Valley Allotment and two permittees are presently authorized to graze cattle in this area - - the Grass Valley Ranch and the Dry Creek Ranch.

Many stands on Bates Mountain contained three age classes of aspen stems (Tables 4 and 5). The largest trees were 120 to 140 years old and there was a second cohort 50 to 55 years of age. These stands also contained an abundance of aspen saplings, which were all 6-8 years of age, as determined by cutting the stems at ground level. The two younger age classes of aspen were apparently related to changes in livestock grazing that occurred over the years. Based on sheep-herder carved dates on aspen trees (Appendix C) and other evidence (Tueller and Monroe 1980:22), there was a major shift from sheep use to cattle use on Bates Mountain after World War II. More recently, the Grass Valley Ranch changed ownership and cattle grazing was substantially reduced from 1992-1995. In addition, the season of use was changed from yearlong to a rotational system that permits grazing only every other year with a reduced number of cattle (Duane Crimmins, BLM Biologist, personal communication, Dec. 2000). Thus, aspen regenerated when herbivory was reduced.

Table 4. Aspen stand parameters in the Simpson Park Mountains.

	Stand Number											
	NV-11	NV-12	NV-13	NV-14	NV-15	NV-16	NV-17	NV-18	NV-19	NV-20	NV-21	NV-22
Section	26	26	26	26	26	26	26	26	26	26	23	23
Township	20N	20N	20N	20N	20N	20N	20N	20N	20N	20N	20N	20N
Range	46E	46E	46E	46E	46E	46E	46E	46E	46E	46E	46E	46E
UTM	520100E 4380000N	520100E 4380000N	520100E 4380000N	520100E 4380000N	520100E 4380000N	520100E 4380000N	520100E 4380000N	520100E 4380000N	520200E 4380300N	520400E 4380600N	520450E 4380800N	520650E 4380850N
Elevation (A)	8500	8500	8500	8500	8500	8500	8500	8500	8420	8300	8200	8200
Aspect	NE	N	N	N	NE	NE	NW	NE	NE	N-NE	NE-N-NW	N
Slope (%)	10-20	10-20	10-15	10-15	20	10	10	10	10-15	5-50	10-40	60-80
Stand size (m)	90x250	40x50	150x500	80x200	50x50	80x200	70x110	80x200	100x300	90x300	100x500	500x500
Regeneration highlined (%)	0	0	0	0	0	0	0	0	NA	0	0	0
Suckers browsed(%)	83	100	77	100	100	0	100	67	100	50	100	0
Stem densities (A)												
<2 m	405	1012	1485	1012	405	472	1080	405	540	2160	2632	1552
2m< < 5cm DBH	1148	1080	6142	5872	135	877	472	5265	0	7155	2632	1688
6-10 cm DBH	0	0	0	0	135	338	0	0	0	1012	0	0
11-20 cm DBH	202	1148	202	270	68	202	607	270	135	202	68	270
>21 cm DBH	135	68	270	135	68	135	68	68	68	202	135	68
Pellet groups*												
Cattle	2	4	2	3	3	0	2	1	11	1	3	0
Deer	0	0	0	0	0	0	0	0	0	0	0	0
Water**	No	No	No	No	No	No	No	No	No	Yes	Yes	No

*Pellet groups per 2x30 m belt transect.
**Water in or near stand.
NA=Not applicable.

Table 4. Aspen stand parameters in the Simpson Park Mountains.

	Stand Number											
	NV-23	NV-24	NV-25	NV-26	NV-27	NV-28	NV-29	NV-30	NV-31	NV-32	NV-33	NV-34
Section	20	20	17	17	18	19	19	19	19	25	25	25
Township	20N	20N	20N	20N	20N	20N	20N	20N	20N	20N	20N	20N
Range	47E	47E	47E	47E	47E	47E	47E	47E	47E	46E	46E	46E
UTM	524950E 4381800N	525200E 4381900N	524800E 4382750N	524600E 4382750N	524650E 4388000N	524600E 4280000N	524000E 4381700N	521850E 4381750N	524350E 4381100N	522850E 4379550N	522850E 4379750N	523000E 4380000N
Elevation (A)	8800	8600	8080	8160	8200	8500	8220	8140	8560	8560	8520	8400
Aspect	E-NE	NW	NE	NE	NE	W-NW	N-NW	N-NW	N-NW	NE-E	E	E
Slope (%)	10-60	40-50	10-20	20-40	20-40	10-60	10-50	10-60	30-50	10	10-40	60-80
Stand size (m)	80x300	50x70	50x200	80x100	60x90	100x150	90x200	80x150	70x100	30x40	70x100	100x200
Regeneration highlined (%)	0	0	100	0	0	0	0	0	0	NA	100	0
Suckers browsed(%)	0	0	100	82	0	0	0	0	0	100	100	8
Stem densities (A)												
<2 m	1215	3308	1958	1890	1080	1148	1552	1152	2902	810	1620	1620
2m< < 5cm DBH	4658	5265	135	3510	3848	5602	3848	7695	4185	0	68	5198
6-10 cm DBH	608	202	0	0	0	0	0	0	0	0	0	0
11-20 cm DBH	202	135	202	270	135	135	472	202	135	135	202	338
>21 cm DBH	135	68	68	135	68	68	202	68	68	68	68	68
Pellet groups*												
Cattle	0	0	4	1	0	0	0	0	0	17	5	0
Deer	0	0	0	0	0	0	0	0	0	0	0	0
Water**	No	No	Yes	No	No	No	Yes	No	No	Yes	Yes	No

*Pellet groups per 2x30 m belt transect.
**Water in or near stand.
NA=Not applicable.

Table 4. Aspen stand parameters in the Simpson Park Mountains.

	Stand Number				
	NV-35	NV-36	NV-37	NV-38	NV-39
Section	19	19	19	24	19
Township	20N	20N	20N	20N	20N
Range	47E	47E	47E	46E	47E
UTM	523250E 4380800N	523300E 4381050N	523300E 4381300N	523050E 4381350N	523500E 4380750N
Elevation (A)	8120	8080	8020	8200	8300
Aspect	N	N-NW	N	E-NE	NW
Slope (%)	5-10	5-10	5-10	20-80	40-80
Stand size (m)	100x300	100x200	80x100	200x500	100x400
Regeneration highlined (%)	100	NA	NA	0	0
Suckers browsed(%)	100	100	100	0	0
Stem densities (A)					
<2 m	1215	945	608	2092	878
2m< < 5cm DBH	202	0	0	7020	5940
6-10 cm DBH	0	0	0	0	0
11-20 cm DBH	338	202	135	68	68
>21 cm DBH	68	135	135	68	68
Pellet groups*					
Cattle	5	3	11	0	0
Deer	0	0	0	0	0
Water**	Yes	Yes	Yes	No	No

*Pellet groups per 2x30 m belt transect.
**Water in or near stand.
NA=Not applicable.

Table 5. Age and diameter of aspen in the Simpson Park Mountains.

Stand Number	Stem Diameter (cm)/Age (yrs)
NV-11	2/7, 3/7, 4/8, 4/8, 16/49, 18/54, 36/129, 42/135
NV-12	2/6, 3/8, 4/8, 16/50, 19/56, 37/126, 44/138
NV-13	5/4, 5/7, 5/8, 5/8, 16/52, 19/59, 42/108, 44/118
NV-14	3/7, 3/7, 4/8, 4/8, 4/8, 18/50, 19/53, 33/137, 34/129
NV-15	2/6, 3/10, 3/14, 4/9, 9/48, 11/52, 16/50, 19/52, 35/124
NV-16	2/6, 3/8, 3/15, 4/9, 4/12, 4/18, 8/22, 9/24, 15/34, 16/35, 16/35, 24/55, 37/122
NV-17	4/8, 4/8, 5/9, 13/52, 14/50, 15/52, 19/62, 36/118
NV-18	4/8, 4/8, 5/9, 17/50, 19/52, 38/125
NV-19	18/50, 40/128
NV-20	4/8, 4/8, 9/19, 16/44, 46/122, 48/130
NV-21	4/8, 4/8, 5/9, 18/52, 42/120
NV-22	3/7, 4/8, 4/8, 5/9, 11/55, 15/58, 30/126
NV-23	3/8, 4/8, 4/8, 6/12, 8/15, 8/16, 8/14, 10/18, 11/22, 13/42, 20/94, 31/100, 32/118
NV-24	3/8, 4/8, 4/9, 5/10, 6/18, 7/20, 8/21, 15/50, 23/84, 27/R*, 29/R*, 30/115
NV-25	2/7, 3/7, 4/7, 4/8, 4/10, 15/R*, 17/R*, 18/52, 19/55, 20/R*, 44/130, 52/128, 55/R*
NV-26	4/8, 4/8, 5/8, 14/50, 16/52, 24/122
NV-27	4/8, 4/7, 5/8, 16/50, 18/54, 22/120
NV-28	4/8, 4/8, 17/50, 19/50, 23/125, 27/120
NV-29	4/8, 4/8, 5/9, 13/46, 16/51, 18/54, 36/127, 38/130
NV-30	4/8, 4/8,5/9, 16/56, 17/50, 18/51, 28/120
NV-31	3/7, 4/8, 4/8, 5/9, 14/48, 16/54, 22/92
NV-32	18/50, 22/54, 52/130
NV-33	4/8, 4/8, 5/9, 18/50, 20/50, 34/120
NV-34	4/8, 5/8, 6/9, 17/50, 18/52, 21/56, 38/115
NV-35	4/8, 5/8, 19/50, 22/56, 48/R*, 52/R*
NV-36	18/50, 22/50, 45/110, 45/115
NV-37	19/50, 20/52, 46/108, 48/115
NV-38	4/8, 4/8, 5/8, 6/9, 18/50, 34/R*, 36/115
NV-39	4/8, 4/8, 5/9, 6/9, 28/120

*Stem with heart rot that could not be aged.

Not all aspen stands, though, exhibited this pattern. Some lacked the 50-55 year regeneration event, as well as the 6-8 year regional episode (Figure 11), while others lacked only the more recent age class (Figure 9). These patterns are apparently related to slope and distance from water (Figures 9-14). Aspen stands on flat areas were less likely to regenerate (Figure 9, 11, and 13) than aspen growing on steeper slopes (Figures 10, 12, and 13), while aspen growing near springs or streams was also less likely to have regenerated (Figure 14). In addition, aspen stands on flatter areas near water also had fewer grass and forbs, and more bare soil, in their understories than aspen growing on steep slopes far from water (Table 6). As cattle prefer gentle slopes near water (Holechek 1988), the observed patterns in aspen stem dynamics and understory species composition are likely related to past, site-specific, livestock use; i.e., the aspen stands most heavily used by cattle have not successfully produced new stems > 2m tall. This conclusion is supported by observations of aspen protected by fallen trees and aspen protected inside the Bates Mountain Exclosure.

Similar to conditions in the Shoshone Mountains (Figure 8), aspen on Bates Mountain successfully regenerated where emergent suckers have been protected by the interlocking branches of fallen trees (Figure 15). Again, this is an indication that repeated browsing, not other factors, is responsible for the failure of these stands to produce new aspen stems >2 m tall (Ripple and Larsen 2001).

The Bates Mountain Exclosure (BLM 4245) was built in 1965 by BLM, the Nevada Division of Wildlife, and the University of Nevada at Reno to study mule deer-cattle forage utilization and food habits (Tueller 1979, Tueller and Monroe 1980). The

Table 6. Understory species composition of aspen stands in the Simpson Park Mountains. T=trace.

Species	Stand Number and Percent Canopy Cover												
	NV-11	NV-12	NV-13	NV-14	NV-15	NV-16	NV-17	NV-18	NV-19	NV-20	NV-21	NV-22	NV-23
Big sagebrush	5	10	T	T	10	T	-	T	-	-	-	-	T
Green rabbitbrush	20	5	-	-	5	-	T	T	T	-	-	-	-
Currant	-	-	T	T	-	T	-	-	T	-	-	5	-
Snowberry	-	-	-	T	T	-	5	-	T	-	T	50	T
Willow	-	-	-	-	-	-	-	-	-	-	-	-	-
Rose	-	-	-	-	-	-	-	-	-	-	-	-	-
Grasses	15	5	T	5	5	80	10	15	T	T	5	10	25
Forbs	10	5	T	T	5	10	10	10	10	T	5	10	25
Bare soil	10	30	20	30	20	T	15	5	60	10	20	-	-
Litter	40	35	60	55	40	10	50	55	20	55	70	15	35
Rock	T	5	-	5	5	T	5	T	T	5	T	5	5
Downed aspen	T	5	20	5	10	T	5	15	10	30	T	5	10

Table 6. Understory species composition of aspen stands in the Simpson Park Mountains. T=trace.

	Stand Number and Percent Canopy Cover												
Species	NV-24	NV-25	NV-26	NV-27	NV-28	NV-29	NV-30	NV-31	NV-32	NV-33	NV-34	NV-35	NV-36
Big sagebrush	T	T	T	T	T	T	T	T	T	10	5	T	5
Green rabbitbrush	10	-	T	T	5	T	T	T	T	5	-	T	T
Currant	-	T	T	-	-	-	-	T	-	-	-	-	-
Snowberry	T	-	25	40	50	20	20	20	T	10	15	T	T
Willow	-	T	-	-	-	-	-	-	-	-	-	-	-
Rose	-	-	-	5	-	-	-	-	-	-	-	-	-
Grasses	50	10	15	10	15	10	10	15	T	5	T	5	10
Forbs	15	10	10	10	10	10	10	15	T	5	T	10	10
Bare soil	-	35	5	T	T	T	T	T	65	50	5	60	35
Litter	25	40	40	25	20	50	50	40	10	10	65	15	35
Rock	-	T	T	T	T	T	T	T	20	5	T	T	T
Downed aspen	T	5	5	10	T	10	10	10	5	5	10	10	5

Table 6. Understory species composition of aspen stands in the Simpson Park Mountains. T=trace.

	Stand Number and Percent Canopy Cover		
Species	NV-37	NV-38	NV-39
Big sagebrush	T	T	T
Green rabbitbrush	T	5	-
Currant	-	-	T
Snowberry	-	20	40
Willow	T	-	-
Rose	-	-	-
Grasses	10	25	25
Forbs	10	25	20
Bare soil	50	T	T
Litter	30	25	10
Rock	T	T	T
Downed aspen	T	5	5

Figure 9. The effect of slope on the ability of Bates Mountain aspen to successfully regenerate. Shown is aspen stand NV-19 where cattle tend to concentrate because of the site's gentle slope (10-15%) and location near water (Holechek 1988). The oldest trees in this stand were approximately 130 years of age and there were a few trees in the 50-55 year age class, but, unlike much of Bates Mountain, aspen had not recently regenerated. Compare Figures 9 and 11 with Figures 10 and 12. The understory of this aspen stand was dominated by bare soil (60%). Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 172) by Charles E. Kay; August 20, 2000.

Figure 10. The effect of slope on the ability of Bates Mountain aspen to successfully produce new stems >2 m tall. Shown is aspen stand NV-22, which is near the stand pictured in Figure 9. Cattle make less use of this area, however, because of its steeper slope (60-80%) and its greater distance from water (Holechek 1988). The oldest trees in this stand were also approximately 130 years of age and there was a regeneration event 50-55 years ago, but unlike the stand in Figure 9, there was also a major regeneration event 6-8 years ago. Grasses, forbs, and shrubs combined for 75% canopy cover and there was no exposed soil. Compare Figures 9 and 11 with Figures 10 and 12. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 181) by Charles E. Kay; August 20, 2000.

Figure 11. The effect of slope on the ability of Bates Mountain aspen to regenerate. This stand is on a flat area in an open valley near water and has not successfully produced new aspen stems >2 m tall in nearly 130 years. Compare Figures 9 and 11 with Figures 10 and 12. Print from color slide (Appendix C - - No. 266) by Charles E. Kay; August 22, 2000.

Figure 12. The effect of slope on the ability of Bates Mountain aspen to produce new stems >2 m tall. Shown is aspen stand NV-34. Cattle make less use of this area because of its steeper slope (60-80%) and its distance from water (Holechek 1988). The largest trees in this stand were 115 years of age and there also were trees in the 50-55 year size class. In addition, there was a major regeneration event 6-8 years ago. Note that the newly regenerated aspen had branches all the way to the ground and showed no sign of ungulate browsing or highlining, as would be the case if mule deer numbers were excessive (Kay and Bartos 2000). Print from color slide (Appendix C - - No. 237) by Charles E. Kay; August 22, 2000.

Figure 13. The effect of slope on the ability of Bates Mountain aspen to successfully produce new stems >2 m tall. This aspen stand is situated along both sides of the North Fork of Stiner Creek, although the stream is dry at this point. Nevertheless, on the flat area to the right of the stream channel, aspen has not successfully regenerated in recent years, while aspen in the same clone, but on the steeper hillside to the left of the stream channel, has regenerated. This phenomena is common in central Nevada. Aspen stands, or parts of aspen stands on more gentle slopes are more heavily used by cattle and generally lack regeneration, while stands or part of stands on adjacent, but steeper slopes, have successfully produced new stems >2 m tall, because livestock use is less in those areas (Holechek 1988). Print from a color slide (Appendix C - - No. 238) by Charles E. Kay; August 22, 2000.

Figure 14. Typical spring on the upper portion of Bates Mountain. This spring is at the head of the South Fork of Stiner Creek and had been heavily used by cattle, as had adjacent aspen communities. Bare soil was common and all riparian vegetation had been utilized to ground level (Clary and Leininger 2000). None of the water sources on Bates Mountain have been developed or fenced to exclude livestock. Red and white survey pole (6 ft) for scale. Print from a color slide (Appendix C - - No. 174) by Charles E. Kay; August 20, 2000.

Figure 15. A de facto aspen exclosure on Bates Mountain. At this and other sites on Bates Mountain, as the older aspen trees have died and fallen, their branches have interlocked and physically prevented access by ungulates, primarily cattle. This has prevented emergent suckers from being browsed and allowed those stems to successfully regenerate (Ripple and Larsen 2001), which suggests that herbivory, not other factors, is responsible for the lack of aspen regeneration in adjacent areas. Red and white survey pole (6 ft) for scale. Print from a color slide (Appendix C - - No. 239) by Charles E. Kay; August 22, 2000.

exclosure was of a three-part design with one part fenced to exclude both wildlife and livestock, while an adjacent area was fenced to exclude cattle, but to permit access by mule deer (deer-use only). The third part was not fenced and was used by both deer and cattle. The exclosure included a mixture of sagebrush, grass, and aspen on deer and cattle summer range.

When this site was visited in August 2000, the total-exclusion part of the exclosure was still functional, though the fence was in recent disrepair. The same was not true for the cattle-exclusion (deer-use only) part of the exclosure. That fence had been down for a number of years, and cattle had been using the "inside" area. Belt transects were established in six aspen stands immediately outside the exclosure (NV-11, 12, 13, 14, 15, and 17) and in the total-exclusion area (NV-16), as well as within the "deer-only" area (NV-18).

Aspen inside the total-exclusion area regenerated shortly after the exclosure was constructed (Tueller and Monroe 1980:92-96) and had developed into a multi-age structured stand (Table 4). Aspen outside the total-exclusion area and within the "deer-only" use area had not regenerated during the 1960's. Instead, aspen-stem dynamics in those areas exhibited the pattern discussed above - - large 120-140 year old trees, 50-55 year old trees, and aspen saplings 6-8 years of age (Tables, Figure 16). There were also major differences in understory species composition. Outside the exclosure, grasses and forbs averaged only 12% canopy cover and all plants had been utilized to ground level (Figure 17, Clary and Leininger 2000). Litter, mostly aspen leaves, covered 47% of ground, while bare soil averaged 21% (Table 6). Within the total-exclusion area,

Figure 16. A typical aspen stand (NV-13) outside the Bates Mountain Exclosure. The largest trees were 110-120 years of age. There was also a 50-55 year age class, as well as an abundance of 6-8 year old aspen saplings (6,142 stems/A). As discussed in the text, many aspen stands on Bates Mountain recently regenerated, without fire or other disturbance, when livestock numbers were reduced. Red and white survey pole (6 ft) for scale. Print from a color slide (Appendix C - - No. 131) by Charles E. Kay; August 20, 2000.

Figure 17. A typical aspen understory (NV-12) outside the Bates Mountain Exclosure. The major cover classes were bare soil (30%) and litter (35%), primarily aspen leaves, while grasses were rare (5%). The lack of understory vegetation is apparently the result of repeated livestock grazing - - compare this with Figure 18 where cattle have been excluded for 35 years. Red and white survey pole in one foot segments for scale. Print from a color slide (Appendix C - - No. 128) by Charles E. Kay; August 20, 2000.

however, grasses and forbs combined for 90% canopy cover (Table 6) and many plants were over 3 ft tall (Figure 18). Litter covered 10% of the soil surface and there was only a trace of bare ground (Table 6). Grass cover also increased in the non-aspen portion of the exclosure and appeared to be replacing sagebrush (Artemisia tridentata) (Figure 19).

This is similar to what was reported in earlier studies. Tueller and Monroe (1980:93) noted that during 1965 and 1966 the average annual production (pounds/A) of grasses and forbs within the aspen community was 10 times greater in the total-exclusion area than where cattle were allowed to graze. According to Tueller and Monroe (1970:94), on outside plots, "Livestock utilized 69.4 percent of the forb production, while deer consumed 10.8 percent during 1965 in both the aspen and sagebrush communities. Deer used insignificant quantities of grass, although livestock consumed nearly all that was available." Tueller and Monroe (1980:92) noted that deer use was relatively low on Bates Mountain during their study, averaging 9.1 deer use days per acre in aspen, but that was still enough to have had an impact on aspen regeneration (Tueller and Monroe 1980:9) - - recall that aspen stand-ages recorded during this study (NV-18, Tables 4 and 5) indicated the aspen inside the deer-only portion of the exclosure did not produce any new stems greater than >2 m tall during the 1960's-1970's, while aspen in the total-exclusion area did.

No deer pellet groups were recorded on any of the belt transects used to measure aspen on Bates Mountain during the present study (Table 4). I did see a few mule deer and some deer pellet groups while I was on the mountain, but deer numbers

Figure 18. Typical understory vegetation inside the Bates Mountain Exclosure (NV-16). Unlike aspen understories outside the exclosure, which were primarily leaf litter and bare soil, forbs and grasses had 90% canopy cover inside the exclosure. This difference cannot be attributed to climatic change or other abiotic factors. Although vegetation production was not measured during the present study, plant production inside the exclosure was probably at least 10 times greater than where cattle have grazed for many years, as was the case in 1965 and 1966 (Tueller and Monroe 1980:92-96). Compare this to Figure 17. Red and white survey pole in one foot segments for scale. Print from a color slide (Appendix C - - No. 146) by Charles E. Kay; August 20, 2000.

Figure 19. Fenceline contrast at the Bates Mountain Exclosure. The protected area is on the right and the grazed area is on the left. Aspen stand NV-15 is on the left and NV-16 on the right. Inside the exclosure, grass was so abundant that it apparently is replacing sagebrush, while outside, what little grass existed had been utilized to ground level by cattle (Clary and Leininger 2000). Print from color slide (Appendix C - - No. 161) by Charles E. Kay; August 20, 2000.

appeared to be very low. I did not encounter the heavy deer use that I have observed in other states (Kay and Bartos 2000). For instance, aspen communities on Bates Mountains that were on steep sites farthest from water were often multi-aged (i.e.; NV-20, 23, and 24), indicative of continual aspen regeneration. Those aspen stands also had a greater proportion of understory vegetation and less bare soil. This would not have been the case if mule deer populations had been excessive (Kay and Bartos 2000). In fact, the recent regeneration event and the lack of highlining of those aspen saplings (Table 4, Figures 10, 12, and 16) suggest that mule deer use on Bates Mountain has not had a major impact on aspen over the last several years. It should be noted, however, that since 1990 mule deer populations throughout northern and central Nevada have declined precipitously due to severe winter weather and have only recently begun to recover (Dobel 1999).

While on Bates Mountain, I also evaluated the condition and trend of aspen communities on the lower portion of Stiner Creek, including the fenced, riparian pasture at the mouth of the canyon (see Appendix A). In some areas, primarily flat sites where cattle tend to concentrate, aspen regeneration was absent and the understory plant communities were heavily grazed (Figure 20, Clary and Leininger 2000). While on other, often adjacent portions of the stream, usually where there was thick brush or steep banks, aspen had regenerated profusely, and some stands were multi-aged (Figure 21, Appendix B). In many stands, there had recently been a major regeneration event like that observed on the rest of Bates Mountain. Aspen within the fenced, riparian pasture appeared similar to aspen above the fence, at least in the sections that were surveyed.

Figure 20. Aspen along the lower portion of Stiner Creek. This flat area is heavily used by cattle (Holechek 1988) and aspen had not successfully regenerated. This was typical of some areas along this stream. On sites with less livestock use, however, aspen had successfully regenerated - - see Figure 21. Red and white survey pole (6 ft) for scale - - note the heavily browed aspen suckers at the base of the survey pole. Print from color slide (Appendix C - - No. 322) by Charles E. Kay; August 23, 2000.

Figure 21. Aspen along the lower portion of Stiner Creek. This area has steeper banks, as well as dense brush, which apparently limits livestock use on this site (Holechek 1988). With reduced herbivory, aspen regenerated and produced a multi-aged stand. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 320) by Charles E. Kay; August 23, 2000.

Diamond Mountains

Aspen stands (NV-40 to NV-74) were measured at two locations within the Diamond Mountains (Appendix C - - slides 335-565). In the southern portion of the Diamond Mountains, aspen was measured in the Sawmill Creek, Cottonwood Creek, and Hildebrand Canyon drainages (Appendix A). While in the northern portion of the range, aspen was measured in the Homestead Canyon, Sheep Canyon, and Threemile Canyon watersheds (Appendix A). As aspen stands in the southern Diamond Mountains exhibited similar conditions and trends, Sawmill, Cottonwood, and Hildebrand were grouped for analysis. Aspen in the other canyons exhibited different patterns and those results are presented separately.

Southern Diamond Mountains

Sawmill, Cottonwood, and Hildebrand Canyons are all in the Black Point Allotment, which has changed ownership four times since 1983 (Joe Ratliff, BLM Soil Scientist, personal communication, Dec. 2000). In general, cattle have grazed this allotment from early May until the end of October, or throughout the entire growing season. There also has been some use by domestic sheep, but the number of cattle has remained relatively constant over the yeas. That is to say, according to BLM records there have not been any major changes in the number of AUM's or seasons of use authorized on this allotment, at least since 1980.

This grazing history is reflected in the condition and trend of aspen communities. Unlike Bates Mountain where there was a major aspen regeneration event 6 to 8 years ago when cattle use was temporarily reduced, aspen stem dynamics (Table 7) and age structure (Table 8) data do not exhibit any regeneration pulses in the southern Diamond Mountains. Instead, aspen regeneration appears to be related to site-specific cattle grazing patterns (Holechek 1988). Of the 20 stands measured in these drainages (NV-40 to NV-59), 80 cow pellet groups were recorded on the aspen belt-transects, but only two for mule deer. That is to say, most herbivory in this area was attributable to livestock, not wildlife.

Similar to other areas of central Nevada, there was a marked effect of slope on the ability of aspen in the southern Diamond Mountains to successfully produce new stems >2 m tall. On areas with gentle slopes, aspen generally had not regenerated (Figure 22), as livestock tend to concentrate on those areas (Tables 7 and 8; Holechek 1988). Conversely, aspen on steep hillsides had successfully regenerated over many years and produced stands that were often multi-aged (Figure 23). While there were no fenced, aspen-containing exclosures on this allotment, there were several de facto exclosures. Even on flat areas near water, aspen in the southern Diamond Mountains successfully regenerated where it was protected from livestock by fallen trees (Figure 24) or steep, stream-cut banks (Figure 25). This suggests that aspen can regenerate under present environmental conditions, if ungulate herbivory is controlled.

Unlike Elephant Head in the Shoshone Mountains or Bates Mountain in the Simpson Park Range, aspen stands in the southern Diamond Mountains, on average,

Table 7. Aspen stand parameters in the Diamond Mountains.

	Stand Number											
	NV-40	NV-41	NV-42	NV-43	NV-44	NV-45	NV-46	NV-47	NV-48	NV-49	NV-50	NV-51
Section	13	13	11	13	13	13	24	24	24	24	23	23
Township	20N	20N	20N	20N	20N	20N	20N	20N	20N	20N	20N	20N
Range	54E	54E	54E	54E	54E	54E	54E	54E	54E	54E	54E	54E
UTM	599000E 4384400N	598900E 4384500N	597800E 4384900N	598700E 4383800N	598750E 4383800N	599300E 4383500N	599950E 4382300N	599600E 4381900N	599500E 4381500N	598800E 4381850N	598650E 4381800N	598450E 4381750E
Elevation (A)	7360	7300	6920	7340	7360	7600	8200	7900	7900	7540	7500	7420
Aspect	NW	W	NW	W	W	N	S-SW	SW-W-NW	W-NW	SW-W-NW	W-NW-N	W-NW-N
Slope (%)	5-10	5	5-10	10-15	10-15	5-15	40-60	5-20	5-15	5-10	5-20	10-15
Stand size (m)	50x60	100x500	30x50	100x600	100x600	100x300	50x100	100x150	40x100	100x200	100x200	60x100
Regeneration highlined (%)	100	NA	NA	NA	100	NA	100	NA	100	100	100	100
Suckers browsed(%)	100	100	100	100	100	100	36	100	100	100	100	100
Stem densities (A)												
<2 m	810	1282	878	1080	1350	1350	945	2025	945	2025	1552	2700
2m< < 5cm DBH	68	0	0	0	405	0	1418	0	202	135	135	68
6-10 cm DBH	135	0	0	0	135	0	338	0	338	135	135	270
11-20 cm DBH	0	0	0	0	0	0	0	0	0	0	0	0
>21 cm DBH	135	202	135	135	68	202	270	135	68	135	68	135
Pellet groups*												
Cattle	4	8	4	9	2	5	0	7	3	7	4	3
Deer	0	0	0	0	0	0	2	0	0	0	0	0
Domestic sheep	0	0	0	0	0	0	0	0	0	0	0	0
Water**	No	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes

*Pellet groups per 2x30 m belt transect.
**Water in or near stand.
NA=Not applicable.

Table 7. Aspen stand parameters in the Diamond Mountains.

	Stand Number											
	NV-52	NV-53	NV-54	NV-55	NV-56	NV-57	NV-58	NV-59	NV-60	NV-61	NV-62	NV-63
Section	19	19	19	19	13	13	13	13	12	12	12	12
Township	20N	20N	20N	20N	20N	20N	20N	20N	22N	22N	22N	22N
Range	55E	55E	55E	55E	54E	54E	54E	54E	54E	54E	54E	54E
UTM	600750E 4383150N	600600E 4383350N	600450E 4383500N	600450E 4383600N	599850E 4383750N	600300E 4383950N	600100E 4383850N	600000E 4384050N	598000E 4406500N	598700E 4406500N	599400E 4406400N	599750E 4406450N
Elevation (A)	8600	8350	8160	8100	7900	7900	7800	7750	6500	6550	6800	6950
Aspect	NW	NW	W-NW	W	NW-N	SW	N-NW	S-SW-W	W	W	W	W
Slope (%)	60-80	60-80	10-20	5-10	30	20-30	5-30	5-20	5-10	5-10	15	10-15
Stand size (m)	200x300	100x200	60x100	50x60	80x80	50x70	60x130	50x200	50x100	50x250	50x200	30x100
Regeneration highlined (%)	0	0	0	NA	100	100	100	NA	100	100	100	NA
Suckers browsed(%)	0	0	100	100	100	100	100	100	100	100	100	100
Stem densities (A)												
<2 m	2295	1958	945	810	878	1485	2295	1418	472	540	675	472
2m< < 5cm DBH	1282	1012	68	0	135	68	135	0	33075	41446	23760	0
6-10 cm DBH	472	338	0	0	135	68	68	0	3578	3308	2498	0
11-20 cm DBH	270	135	0	0	0	0	0	0	0	0	0	0
>21 cm DBH	135	68	135	68	135	135	68	135	0	0	0	68
Pellet groups*												
Cattle	0	0	2	7	2	3	3	7	2	3	0	0
Deer	0	0	0	0	0	0	0	0	0	0	0	0
Domestic sheep	0	0	0	0	0	0	0	0	56	84	54	92
Water**	No	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes

*Pellet groups per 2x30 m belt transect.
**Water in or near stand.
NA=Not applicable.

Table 7. Aspen stand parameters in the Diamond Mountains.

	Stand Number										
	NV-64	NV-65	NV-66	NV-67	NV-68	NV-69	NV-70	NV-71	NV-72	NV-73	NV-74
Section	6	7	7	7	7	13	13	26	25	26	26
Township	22N	22N	22N	22N	22N	22N	22N	23N	23N	23N	23N
Range	55E	55E	55E	55E	55E	54E	54E	54E	54E	54E	54E
UTM	600400E 4406750N	600700E 4404800N	500500E 4404700N	600800E 4404600N	600350E 4404650N	599800E 4404600N	599500E 4404500N	598600E 4410750N	598700E 4410700N	599200E 4410700N	600400E 4411000N
Elevation (A)	7300	7300	7300	7400	7120	6900	6780	6300	6340	6480	6900
Aspect	W-SW	W-NW	NE	NE-N-NW	W-NW	W	W	SW	W	W	W
Slope (%)	30	20-30	20-30	10-60	20-30	10-20	10	5	5	5	10
Stand size (m)	30x100	50x80	70x100	100x400	50x100	60x200	30x150	25x50	20x300	20x250	40x60
Regeneration highlined (%)	100	100	100	100	100	100	100	0	0	0	0
Suckers browsed(%)	100	100	100	100	100	100	100	0	0	0	0
Stem densities (A)											
<2 m	472	878	1882	1350	1552	1215	1215	810	945	1148	1215
2m< < 5cm DBH	68	202	2565	2970	3172	810	11880	3712	878	1012	1148
6-10 cm DBH	338	135	338	405	405	270	1282	945	202	405	202
11-20 cm DBH	0	0	0	0	0	0	0	202	135	202	68
>21 cm DBH	68	135	68	202	68	135	0	135	68	135	135
Pellet groups*											
Cattle	0	0	0	1	0	2	6	0	0	0	0
Deer	0	0	0	0	0	0	0	0	0	0	0
Domestic sheep	47	12	11	7	39	29	55	0	0	0	0
Water**	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

*Pellet groups per 2x30 m belt transect.
**Water in or near stand.
NA=Not applicable.

Table 8. Age and diameter of aspen in the Diamond Mountains.

Stand Number	Stem Diameter (cm)/Age (yrs)
NV-40	3/12, 4/14, 5/16, 8/17, 9/18, 13/29, 33/68, 40/75, 41/79
NV-41	48/97, 50/100
NV-42	39/96, 42/102
NV-43	26/52, 26/59, 42/95, 44/97
NV-44	2/5, 3/6, 3/6, 3/6, 4/9, 10/21, 10/20, 12/23, 20/55, 42/95
NV-45	52/103
NV-46	3/11, 4/16, 4/20, 4/20, 4/17, 5/20, 6/18, 7/18, 8/18, 23/82, 24/84
NV-47	30/85, 32/87
NV-48	3/7, 3/8, 3/12, 3/13, 4/17, 5/15, 7/18, 8/18, 8/20, 10/25, 30/85, 34/88
NV-49	4/7, 4/7, 10/20, 12/19, 18/28, 22/26, 26/55, 28/56
NV-50	4/8, 4/9, 12/22, 14/25, 36/87, 38/85
NV-51	3/6, 3/8, 4/8, 4/12, 5/18, 11/26, 13/33, 13/35, 15/40, 19/47, 22/58, 22/79, 38/84, 34/86
NV-52	3/8, 3/6, 3/8, 3/14, 4/15, 5/17, 5/18, 5/12, 8/20, 11/24, 15/48, 16/49, 22/58, 24/60
NV-53	2/8, 3/17, 4/18, 8/20, 10/25, 16/42, 18/45, 22/57, 25/62
NV-54	2/6, 3/8, 22/44, 24/46, 39/87, 40/88
NV-55	18/42, 22/45, 40/87, 42/90
NV-56	4/18, 6/20, 7/19, 8/22, 10/22, 12/40, 17/52, 20/57, 31/85, 32/87
NV-57	3/8, 4/10, 10/20, 11/22, 22/55, 24/57, 32/85, 35/R*, 36/89, 52/122, 55/R*
NV-58	3/8, 3/8, 4/9, 6/18, 8/16, 14/R*, 15/R*, 22/R*, 36/87
NV-59	36/85, 38/88
NV-60	3/8, 3/9, 3/9, 3/11, 9/11, 9/11, 9/11, 10/11
NV-61	3/9, 3/10, 4/11, 9/11, 9/11, 10/11
NV-62	8/11, 9/11, 9/11, 10/11
NV-63	32/118
NV-64	11/28, 12/26, 12/28, 14/30, 44/108
NV-65	3/13, 4/15, 4/16, 5/17, 7/23, 11/30, 14/29, 31/88, 34/R*, 40/R*
NV-66	2/10, 3/12, 5/13, 6/17, 7/19, 7/19, 8/19, 8/22, 29/87, 29/88
NV-67	3/11, 3/12, 5/17, 6/18, 9/19, 10/20, 31/87, 34/87
NV-68	4/14, 4/16, 6/16, 7/19, 8/19, 9/23, 10/24, 40/R*, 42/90
NV-69	3/12, 4/14, 5/16, 6/18, 11/22, 14/20, 40/97, 44/102
NV-70	4/9, 5/10, 9/11, 9/11, 10/11
NV-71	3/2, 4/10, 5/12, 6/14, 7/17, 8/15, 9/19, 11/24, 13/28, 14/R*, 15/28, 28/75, 30/R*, 32/R*
NV-72	4/8, 5/10, 6/11, 7/15, 7/14, 11/16, 13/24, 13/25, 14/22, 15/29, 22/44, 32/62, 40/73
NV-73	4/8, 4/9, 5/11, 6/12, 13/20, 14/23, 15/26, 22/45, 26/48, 32/60, 41/75
NV-74	4/8, 4/9, 8/14, 9/13, 12/18, 15/26, 16/30, 23/42, 24/47, 30/60, 34/71

*Stem with heart rot that could not be aged.

Table 9. Understory species composition of aspen stands in the Diamond Mountains. T=trace.

Species	NV-40	NV-41	NV-42	NV-43	NV-44	NV-45	NV-46	NV-47	NV-48	NV-49	NV-50	NV-51
	Stand Number and Percent Canopy Cover											
Big sagebrush	10	10	10	10	5	-	5	T	5	5	5	10
Snowberry	5	T	-	5	T	T	5	5	10	5	20	10
Chokecherry	T	5	5	10	10	20	25	5	40	5	20	T
Green rabbitbrush	T	T	T	-	-	-	-	-	-	T	T	-
Willow	-	T	-	T	T	T	-	-	-	-	-	-
Rose	-	-	T	5	30	10	-	T	-	5	-	-
Serviceberry	-	T	T	T	-	T	-	-	-	-	-	T
Oregon grape	-	-	-	-	-	-	15	-	-	-	-	-
Elderberry	-	-	-	-	-	-	-	-	-	-	-	-
Red osier dogwood	-	-	-	-	-	-	-	-	-	-	-	-
Currant	-	-	-	-	-	-	-	-	-	-	-	-
Rubber rabbitbrush	-	-	-	-	-	-	-	-	-	-	-	-
										-	-	-
Grasses	50	60	50	35	20	35	30	25	10	20	20	20
Forbs	10	10	10	10	10	10	5	10	5	10	5	10
Bare soil	10	5	5	10	10	5	T	30	15	30	15	30
Litter	15	10	15	10	10	15	10	20	15	20	10	20
Rock	T	T	T	T	T	T	T	T	T	T	T	-
Downed aspen	5	5	5	5	5	5	5	5	5	T	5	T

Table 9. Understory species composition of aspen stands in the Diamond Mountains. T=trace.

	Stand Number and Percent Canopy Cover											
Species	NV-52	NV-53	NV-54	NV-55	NV-56	NV-57	NV-58	NV-59	NV-60	NV-61	NV-62	NV-63
Big sagebrush	T	T	T	5	5	T	T	5	-	-	-	-
Snowberry	60	50	15	10	5	5	10	5	-	-	-	-
Chokecherry	T	T	5	10	30	40	15	T	-	-	5	20
Green rabbitbrush	-	-	-	T	5	-	-	10	-	-	-	-
Willow	-	-	-	-	-	-	-	5	10	10	5	-
Rose	-	-	-	-	-	-	-	T	10	10	10	5
Serviceberry	-	-	-	-	-	-	-	-	-	-	-	T
Oregon grape	-	-	-	-	-	-	-	-	-	-	-	-
Elderberry	T	-	-	-	-	-	-	-	-	-	-	-
Red osier dogwood	-	-	-	-	-	-	-	-	T	-	-	-
Currant	-	-	-	-	-	-	-	-	-	T	-	-
Rubber rabbitbrush	-	-	-	-	-	-	-	-	-	-	-	-
Grasses	10	-	10	10	10	5	5	20	15	15	10	10
Forbs	15	-	10	10	10	10	10	5	15	15	10	5
Bare soil	T	T	30	35	25	25	35	30	30	30	25	50
Litter	10	10	25	20	10	15	15	15	20	20	30	10
Rock	T	T	T	T	T	T	T	T	T	T	T	T
Downed aspen	5	T	5	T	T	T	10	5	T	T	5	T

Table 9. Understory species composition of aspen stands in the Diamond Mountains. T=trace.

	Stand Number and Percent Canopy Cover										
Species	NV-64	NV-65	NV-66	NV-67	NV-68	NV-69	NV-70	NV-71	NV-72	NV-73	NV-74
Big sagebrush	5	10	5	-	T	T	T	T	T	T	T
Snowberry	T	5	15	15	5	5	5	-	-	-	-
Chokecherry	20	40	T	15	10	30	-	-	-	-	-
Green rabbitbrush	T	T	-	-	-	-	-	-	T	T	T
Willow	-	-	-	-	T	T	5	-	10	15	30
Rose	-	-	5	-	10	5	40	-	10	15	30
Serviceberry	-	-	-	-	-	5	-	-	-	-	-
Oregon grape	-	-	-	-	-	-	-	-	-	-	-
Elderberry	-	-	T	-	-	-	T	-	-	-	T
Red osier dogwood	-	-	-	-	10	-	5	-	-	-	-
Currant	-	-	T	-	T	-	-	-	-	-	-
Rubber rabbitbrush	-	-	-	-	-	-	-	-	T	T	T
Grasses	15	10	15	10	5	5	10	60	25	30	20
Forbs	5	5	10	5	5	5	5	5	25	25	10
Bare soil	30	10	20	20	40	30	20	5	5	5	T
Litter	20	20	30	30	15	25	10	30	15	10	10
Rock	5	T	T	T	T	T	T	T	5	T	T
Downed aspen	T	T	T	5	T	T	T	T	5	T	T

Figure 22. The effect of slope on the ability of aspen in the southern Diamond Mountains to produce new stems >2 m tall. Shown is stand NV-41 (5% slope), which had not regenerated in 100 years. Cattle tend to concentrate in areas with gentle topography (Holechek 1988) - - note the repeatedly browsed aspen suckers behind the red and white survey pole (6 ft). Print from color slide (Appendix C - - No. 352) by Charles E. Kay; August 24, 2000.

Figure 23. The effect of slope on the ability of aspen in the southern Diamond Mountains to successfully regenerate. Shown is stand NV-52. Cattle seldom use this area because of its steep slope (60-80%) (Holechek 1988) and the stand is multi-aged (Table 7) - - an indication that it had regenerated over many years. Note that none of the aspen show any evidence of ungulate browsing. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 438) by Charles E. Kay; August 25, 2000.

Figure 24. A de facto aspen exclosure in the southern Diamond Mountains. These aspen (NV-58) were protected from livestock by the interlocking branches of fallen trees (Ripple and Larsen 2001). As the aspen grew and the downed trees decomposed, however, cattle were able to reach the regenerating stems and have now consumed or highlined most lower branches. Compare this with Figure 23. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 458) by Charles E. Kay; August 26, 2000.

Figure 25. Another type of de facto aspen exclosure in the southern Diamond Mountains. Aspen along this section of Cottonwood Creek has not been able to successfully regenerate except where the stream had downcut and aspen was protected within those steep banks. Note the red and white survey pole (6 ft) in the creek bed and how aspen there successfully produced new stems >2 m tall, while aspen in the background had not. Print from color slide (Appendix C - - No. 366) by Charles E. Kay; August 24, 2000.

had a greater proportion of shrubs in their understories (Table 9). Grasses and forbs were also more common (Table 9), but where present, utilization often approached 100% (Figure 26), especially in riparian areas (Figure 27, Clary and Leininger 2000). The largest trees within individual aspen stands from the southern Diamond Mountains fell into three age categories: 55-65 years old, 80-90, and 95-105 (Table 8). The reasons for this are unclear, but may be related to earlier fire events, which stimulated aspen regeneration in local areas - - similar to what recently happened in Homestead and Sheep Canyons.

Homestead Canyon

Although Homestead Canyon is in the northern Diamond Mountains, it is part of the Black Point Allotment, but this area has been used primarily by domestic sheep, not cattle. Aspen in the lower reaches of Homestead Canyon (NV-60 to NV-62) was burned by wildfire during 1989. Those stands regenerated profusely and contained 25,000-45,000 saplings per acre (Table 7), while up-canyon, unburned stands (NV-63 and 64) had not regenerated or had done so at only 500 stems/A in the uppermost elevation stand. This drainage was heavily used by domestic sheep - - 333 sheep pellet groups on five 2x30 m belt transects - - and all the regenerating aspen had been highlined by grazing animals (Figure 28). Utilization on understory vegetation approached 100% (Figures 28 and 29, Clary and Leininger 2000). Growth of the regenerating aspen, however, was excellent with some stems approaching 20 feet in

Figure 26. The understory of a typical aspen stand (NV-47) in the south Diamond Mountains. Although grass and forb cover in the Diamond Mountains was generally greater than at either Elephant Head or Bates Mountain, utilization still approached 100% (Clary and Leininger 2000) - - compare this with Figure 33. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 414) by Charles E. Kay; August 25, 2000.

Figure 27. A riparian area in the southern Diamond Mountains. Utilization approached 100% (Clary and Leininger 2000) and the aspen stand (NV-49) had not regenerated due to repeated use by cattle. Note the repeatedly browsed aspen suckers. All riparian areas in the southern Diamond Mountains were heavily utilized by livestock. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 422) by Charles E. Kay; August 25, 2000.

Figure 28. Aspen in Homestead Canyon. This stand (NV-60) was overrun by wildfire in 1989 and aspen regenerated profusely (36,500 saplings/A). Livestock, primarily domestic sheep, have since highlined the regenerating aspen and consumed most understory production. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 474) by Charles E. Kay; August 26, 2000.

Figure 29. Aspen in Homestead Canyon. This stand (NV-61) was burned by wildfire during 1989 and aspen regenerated profusely (47,700 saplings/A). Domestic sheep have now highlined the regenerating aspen and consumed nearly all understory plant production (Clary and Leininger 2000). Aspen stem growth, however, has been excellent, as some 11 year old stems were nearly 20 feet tall. At this site, there were 84 sheep pellet groups on the 2x30 m belt transect. Print from color slide (Appendix C -- No. 488) by Charles E. Kay; August 26, 2000.

only 11 years (Figures 28 and 29). Although, BLM records indicate that this area was not fenced after it was burned, it is doubtful if these aspen stands could have regenerated under the current grazing regime. That is to say, sheep may have been excluded for 2-3 years after the fire, allowing the terminal leaders of the new aspen suckers to grow beyond their reach. Unfortunately, BLM has no actual use data for this drainage.

Sheep Canyon

Sheep Canyon (NV-65 to 70) is also within the Black Point Allotment, and like Homestead Canyon, it too has been grazed primarily by domestic sheep. The 1989 wildfire did burn some aspen in the lower portion of the canyon (NV-70) and that stand regenerated profusely (12,000 stems/A) (Table 7). That regeneration, though, has now been heavily browsed and highlined by domestic sheep. Aspen stands in the upper portion of the canyon, which have received less use by sheep, successfully regenerated without fire or other disturbance (Figure 30), albeit at lower stem densities (Table 7). Other areas within the drainage, however, have been more heavily utilized by domestic sheep (Figure 31) and aspen in those areas has not fared as well (Table 7).

Figure 30. Aspen in upper Sheep Canyon. This stand (NV-66) had successfully regenerated without fire or other disturbance because the area receives less use by domestic sheep than other parts of the Canyon - - see Figure 31. Print from color slide (Appendix C - - No. 511) by Charles E. Kay; August 27, 2000.

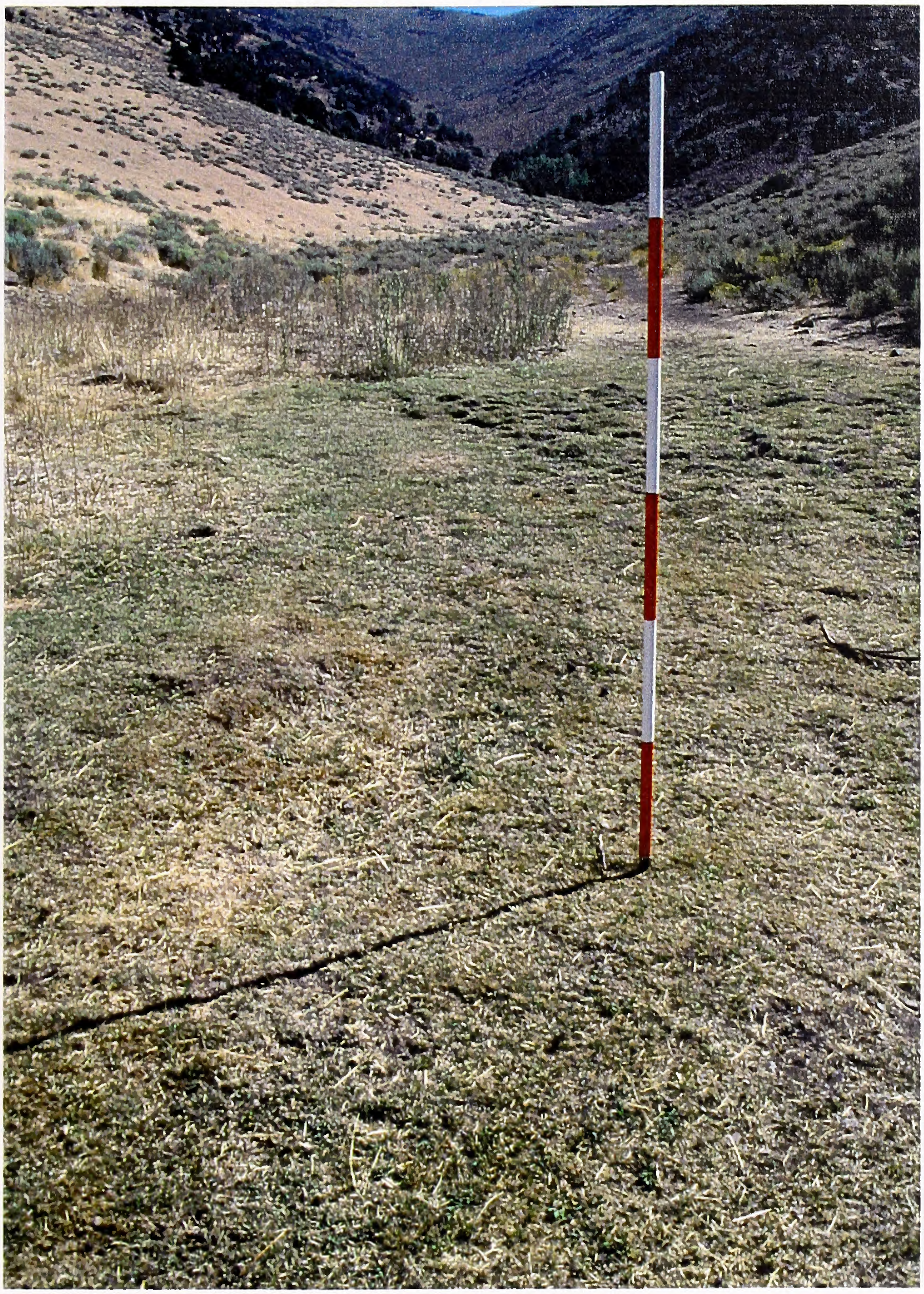

Figure 31. A typical riparian area in Sheep Canyon where utilization approached 100% (Clary and Leininger 2000). Compare this with Figure 33. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 524) by Charles E. Kay; August 26, 2000.

Threemile Canyon

Threemile Canyon is in the Threemile Allotment, which is grazed by cattle, not domestic sheep. For whatever reason, however, this canyon has not actually been grazed by livestock in many years. Although I did observe some cattle sign in the lower reaches of the canyon, all aspen stands had regenerated without fire or other disturbance and exhibited multi-aged stems (Table 7). Moreover, none of the aspen suckers had been browsed and the regenerating aspen had not been highlined (Figure 32), unlike aspen in adjacent Homestead and Sheep Canyons. Grasses carpeted the valley bottom (Figure 33) and palatable shrubs exhibited no signs of browsing. Even curleaf mountain mahogany (Cercocarpus ledifolius), which seldom regenerates anywhere in the West (Schultz et al. 1990, 1991; Davis and Brotherson 1991), produced an abundance of new plants in Threemile Canyon (Figure 34). Since mule deer use is likely similar in Homestead, Sheep, and Threemile Canyons, conditions in Homestead and Sheep can only be attributed to domestic livestock, not wildlife.

Figure 32. A typical aspen stand (NV-71) in Threemile Canyon. This area had not been grazed by livestock for many years and all aspen stands successfully regenerated without fire or other disturbance. Aspen suckers and saplings were unbrowsed and showed no evidence of highlining (Table 7). Moreover, all stands contained multi-aged stems (Table 8). This stand is on a flat site and water is located within 100 ft, yet aspen exhibited no evidence of browsing. Print from color slide (Appendix C - - No. 537) by Charles E. Kay; August 27, 2000.

Figure 33. A typical upland grass community in Threemile Canyon. Compare this with Figures 26, 27, 28, and 31. Although rainfall throughout central Nevada was below normal during 2000, plant growth and production were excellent in Threemile Canyon. This suggests that livestock grazing, not drought, was responsible for the range conditions encountered during the present study. Print from color slide (Appendix C - - No. 562) by Charles E. Kay; August 28, 2000.

Figure 34. A young, unbrowsed, curlleaf mountain mahogany plant in Threemile Canyon. Establishment of curlleaf mountain mahogany from seed is rare throughout the West (Schultz et al. 1990, 1991; Davis and Brotherson 1991), but was common in Threemile Canyon most likely because the latter has not been grazed by livestock for many years. Although mule deer were present, wildlife use was negligible. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 557) by Charles E. Kay; August 28, 2000.

Toiyabe Mountains

Within the Toiyabe Mountains, aspen was measured in the Boone (NV-75 to 79) and Iowa Creek drainages (NV-80 to 84), as well as at the head of Bernd Canyon (NV-85 and 86) and the upper portion of Silver Creek (NV-87) (Appendix A). Boone and Iowa Creeks are in the Austin Allotment, which is grazed by both cattle, primarily at lower elevations, and domestic sheep, primarily on the higher mountains.

Boone Creek

Three exclosures (BLM 4914) were constructed on Boone Creek by BLM in 1990. All three exclosures contain aspen (Appendix A) and aspen had successfully regenerated within each area where cattle have been excluded (NV-76, 77, and 79) (Tables 10 and 11, Figure 35). Aspen, however, had also successfully regenerated within the last 10 years where livestock had not been excluded (NV-78) (Figure 36). This most likely is related to the fact that when the exclosures were built, BLM also mandated that the permittee change the season of use from season-long grazing to only early season grazing (Duane Crimmins, BLM biologist, personal communication, Dec. 2000). Prior to this season of use change, there had been no aspen regeneration along Boone Creek in more than 100 years (Table 11). This is similar to what has been reported in studies of woody riparian vegetation - - changing to early season or dormant season use from season-long grazing has resulted in significant establishment

Table 10. Aspen stand parameters in the Toiyabe Mountains.

	Stand Number												
	NV-75	NV-76	NV-77	NV-78	NV-79	NV-80	NV-81	NV-82	NV-83	NV-84	NV-85	NV-86	NV-87
Section	14	14	14	24	25	29	29	30	19	19	26	26	25
Township	22N	22N	22N	22N	22N	22N	22N	22N	22N	22N	22N	22N	21N
Range	44E	44E	44E	44E	44E	45E	45E	45E	45E	45E	44E	44E	44E
UTM	500000E 4401900N	500400E 4401900N	501250E 4401400N	501750E 4400200N	501800E 4400150N	504600E 4398800N	504700E 4399300N	504100E 4399500N	503600E 4400300N	503600E 4400300N	501300E 4399000N	501300E 4398980N	501350E 4389400N
Elevation (ft)	6580	6640	6750	6970	7000	8100	7840	7540	7300	7300	7400	7400	7100
Aspect	W	W-NW	NW	NW-N	NW	N	NE	NW	N-NE	N-NE	NE	NE	N
Slope (%)	5	5	5	5-20	5-10	20-30	5-10	10-15	30-40	10-20	5-15	5-15	5-20
Stand size (m)	20x100	100x400	40x400	40x400	30x100	100x250	100x200	60x100	50x100	20x40	30x50	30x100	30x70
Regeneration highlined (%)	NA	0	0	20	0	0	0	0	0	0	100	100	100
Suckers browsed(%)	100	0	20	100	0	71	69	83	57	0	100	100	100
Stem densities (A)													
<2 m	202	338	338	472	472	2092	1755	810	472	810	338	675	***
2m< < 5cm DBH	0	8100	4388	4252	3578	4252	5332	1688	810	2160	9382	810	***
6-10 cm DBH	0	608	810	675	405	878	742	0	135	540	1148	0	***
11-20 cm DBH	0	0	0	0	0	338	270	0	68	68	0	0	***
>21 cm DBH	202	202	68	202	68	270	68	68	68	0	68	68	***
Pellet groups*													
Cattle	4	0	0	3	0	1	2	4	1	0	6	5	12
Deer	0	0	1	0	0	0	0	0	0	0	0	0	0
Water**	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	No	No	Yes

*Pellet groups per 2x30 m belt transect.
**Water in or near stand.
***There were only 21 live stems >2 m in the entire stand.
NA=Not applicable.

Table 11. Age and diameter of aspen in the Toiyabe Mountains.

Stand Number	Stem Diameter (cm)/Age (yrs)
NV-75	42/102, 43/R*, 46/R*
NV-76	4/8, 4/10, 5/10, 6/11, 8/12, 40/100, 46/R*, 47/107
NV-77	6/10, 7/11, 45/105, 50/R*
NV-78	5/10, 6/10, 8/12, 36/105, 38/102, 40/103, 42/107
NV-79	3/6, 4/8, 5/10, 8/12, 36/105, 38/103, 40/R*
NV-80	3/14, 3/14, 4/18, 5/18, 7/21, 8/24, 8/24, 9/26, 11/35, 12/38, 14/50, 16/61, 20/70, 24/76, 36/105, 39/115, 46/R*
NV-81	2/16, 3/18, 4/20, 7/23, 8/29, 12/40, 14/52, 20/70, 38/110
NV-82	2/8, 2/10, 3/9, 3/10, 3/10, 3/9, 4/7, 36/110, 38/109
NV-83	2/9, 2/10, 2/11, 5/12, 6/12, 6/10, 12/30, 14/39, 17/48, 20/51, 37/108, 39/110
NV-84	3/8, 4/8, 4/8, 8/10, 9/10, 9/13, 10/12, 20/22
NV-85	4/6, 5/6, 5/7, 6/8, 8/8, 48/95
NV-86	3/4, 3/5, 3/6, 4/6, 50/100
NV-87	40/R*, 43/R*

*Stem with heart rot that could not be aged.

Figure 35. Aspen regeneration inside the lower Boone Creek Exclosure. This area (NV-76) was fenced by BLM in 1990 to exclude livestock and aspen regenerated profusely. Print from color slide (Appendix C - - No. 572) by Charles E. Kay; October 3, 2000.

Figure 36. Aspen regeneration (NV-78) along an unfenced portion of Boone Creek. At the same time the exclosures were constructed on Boone Creek, BLM also changed the season of use on that grazing allotment from virtually season-long to only early season use. AUM numbers, though, were not substantially changed. As reported in other studies (Borman et al. 1999), the season of use change alone reduced utilization on woody species and allowed aspen to successfully produce new stems >2 m tall. Understory species, however, were still heavily utilized. At this site, grasses and forbs had 30% canopy cover while there was 25% bare soil - - compare this with Figure 37. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 592) by Charles E. Kay; October 3, 2000.

and regrowth of woody plants without any reduction in the actual level of grazing; i.e. allotment AUM's were not reduced (Borman et al. 1999). The middle exclosure on Boone Creek showed some recent entry by cattle, and that appeared to have been only a stray cow or two.

While aspen stem dynamics were similar inside and outside the three Boone Creek Exclosures (Tables 10 and 11), there were major differences in understory species composition. Outside the exclosures, utilization was very heavy (Clary and Leininger 2000) and grasses and forbs had an average canopy cover of 22% with 15% bare soil (Table 12, Figure 36). While inside the exclosures, grasses and forbs averaged 75% and there was only a trace of bare soil (Table 12, Figure 37). Riparian areas inside the exclosures also showed substantial improvement (Figure 38).

Iowa Creek

Three exclosures were also built on Iowa Creek by BLM in 1990 (BLM 4915) (Appendix A). The lower exclosure does not contain aspen and was heavily grazed when inspected during early October. Apparently this exclosure had been used as a holding corral for cattle, judging from the amount of use inside the fenced area. The middle exclosure (Appendix A) contains a single, small aspen clone that was over-run by wildfire a few years ago. This exclosure also appears to have been used as a holding corral - - grasses had been heavily utilized and the regenerated aspen stems had all been highlined. Some livestock grazing had also occurred inside the uppermost

Table 12. Understory species composition of aspen stands in the Toiyabe Mountains. T=trace.

	Stand Number and Percent Canopy Cover												
Species	NV-75	NV-76	NV-77	NV-78	NV-79	NV-80	NV-81	NV-82	NV-83	NV-84	NV-85	NV-86	NV-87
Big sagebrush	60	10	20	20	5	T	T	25	10	10	5	20	50
Rubber rabbitbrush	10	-	-	-	-	-	T	-	-	-	-	-	-
Chokecherry	5	5	-	5	T	-	-	-	-	-	30	T	-
Willow	T	5	T	T	-	-	-	-	-	-	-	-	-
Currant	-	-	T	T	T	-	T	5	5	5	5	5	T
Juniper	-	-	T	T	T	-	-	-	T	T	-	-	-
Rose	-	-	-	10	5	-	-	-	-	-	-	T	-
Snowberry	-	-	-	-	-	-	T	5	5	T	T	-	-
Green rabbitbrush	-	-	-	-	-	-	-	T	5	-	-	-	-
Serviceberry	-	-	-	-	-	-	-	-	T	-	-	-	-
Grasses	10	50	50	20	60	15	10	10	20	60	5	5	5
Forbs	5	25	20	10	20	15	5	5	10	15	5	5	5
Bare soil	5	T	T	25	T	30	30	20	10	T	30	40	20
Litter	5	5	5	15	10	40	50	25	35	10	20	20	20
Rock	T	T	T	T	T	T	T	T	T	T	T	T	T
Downed aspen	T	T	5	T	T	T	5	5	T	T	T	5	T

Figure 37. Aspen regeneration (NV-79) inside the upper Boone Creek Exclosure. Height growth was excellent as these aspen stems were only 10 years old. Grasses and forbs were abundant (80%) and there was only a trace of bare soil. Compare this with Figure 36. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 598) by Charles E. Kay; October 3, 2000.

Figure 38. Typical streamside vegetation along Boone Creek in the lower exclosure (NV-76). In the absence of livestock, riparian vegetation nearly conceals the stream from view. Compare this with earlier Figures of grazed riparian areas in central Nevada. Print from color slide (Appendix C - - No. 578) by Charles E. Kay; October 3, 2000.

exclosure (Appendix A), but that use appeared minimal and had not impacted the plant communities, as had happened at the two other exclosures on Iowa Creek. Moreover, the upper exclosure was fenced such that the lower portions of two aspen clones were protected from grazing (Appendix A).

Similar to what was observed on Boone Creek, aspen both inside (NV-84) and outside (NV-83) the upper Iowa Creek Exclosure successfully produced new stems >2 m tall during the last 10 years (Tables 10 and 11). This is not surprising, since BLM changed the season of use on Iowa Creek at the same time the agency modified the grazing permit on Boone Creek (Duane Crimmins, BLM biologist, personal communication, Dec. 2000). Inside the exclosure, however, there was significantly more grasses and forbs and less bare soil than on the outside area (Table 12, Figures 39 and 40).

Aspen regeneration was also measured in the Iowa Creek basin above the three exclosures (Appendix A). There, the more accessible stands had generally regenerated within the last 10 years, but not during the proceeding 100 years (Tables 10 and 11). Again, this recent regeneration event (Figure 41) is most likely related to the season of use changes implemented by BLM in 1990. Aspen stands on steep slopes, and far from water in the uppermost reaches of Iowa Creek, however, were multi-aged (Tables 10 and 11, Figure 42). Those stands regenerated over many years, because cattle use those areas less frequently than they do more gentle areas closer to water (Holechek 1988).

Figure 39. Understory vegetation outside the upper Iowa Creek Exclosure (NV-83). Although aspen outside the exclosure had been able to regenerate under the new grazing regime implemented by BLM in 1990, cattle still heavily utilized understory species (Clary and Leininger 2000). Grass and forb cover (30%) was also less than inside the exclosure (75%). Compare this with Figure 40. Red and white survey pole in one foot increments for scale. Print from color slide (Appendix C - - No. 633) by Charles E. Kay; October 4, 2000.

Figure 40. Understory vegetation inside the upper Iowa Creek Exclosure (NV-84). Not only had aspen regenerated where protected, but understory species also responded positively. Compare this with Figure 39. Red and white survey pole in one foot increments for scale. Print from color slide (Appendix C - - No. 642) by Charles E. Kay; October 4, 2000.

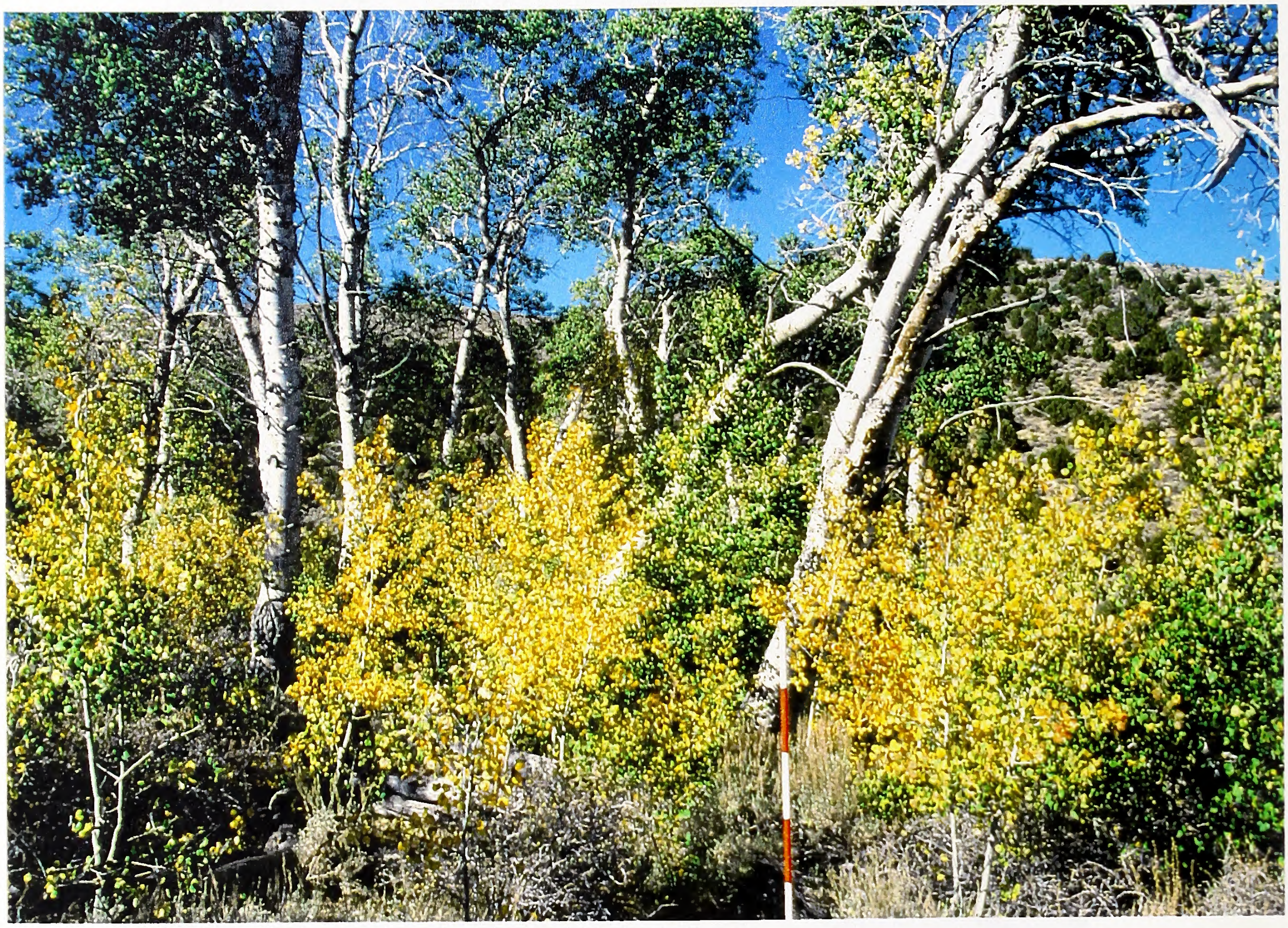

Figure 41. The response of aspen to season of use changes implemented by BLM on Iowa Creek. This stand (NV-82) is on a gentle slope near water and had not regenerated for 100 years prior to 1990 due to heavy utilization by livestock (Holechek 1988). In 1990, BLM changed the timing of grazing from virtually season-long to only early season use, but did not otherwise alter AUM numbers. The change in timing of grazing alone, however, was enough to allow aspen to regenerate on this and other sites in Iowa and Boone Creeks. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 625) by Charles E. Kay; October 4, 2000.

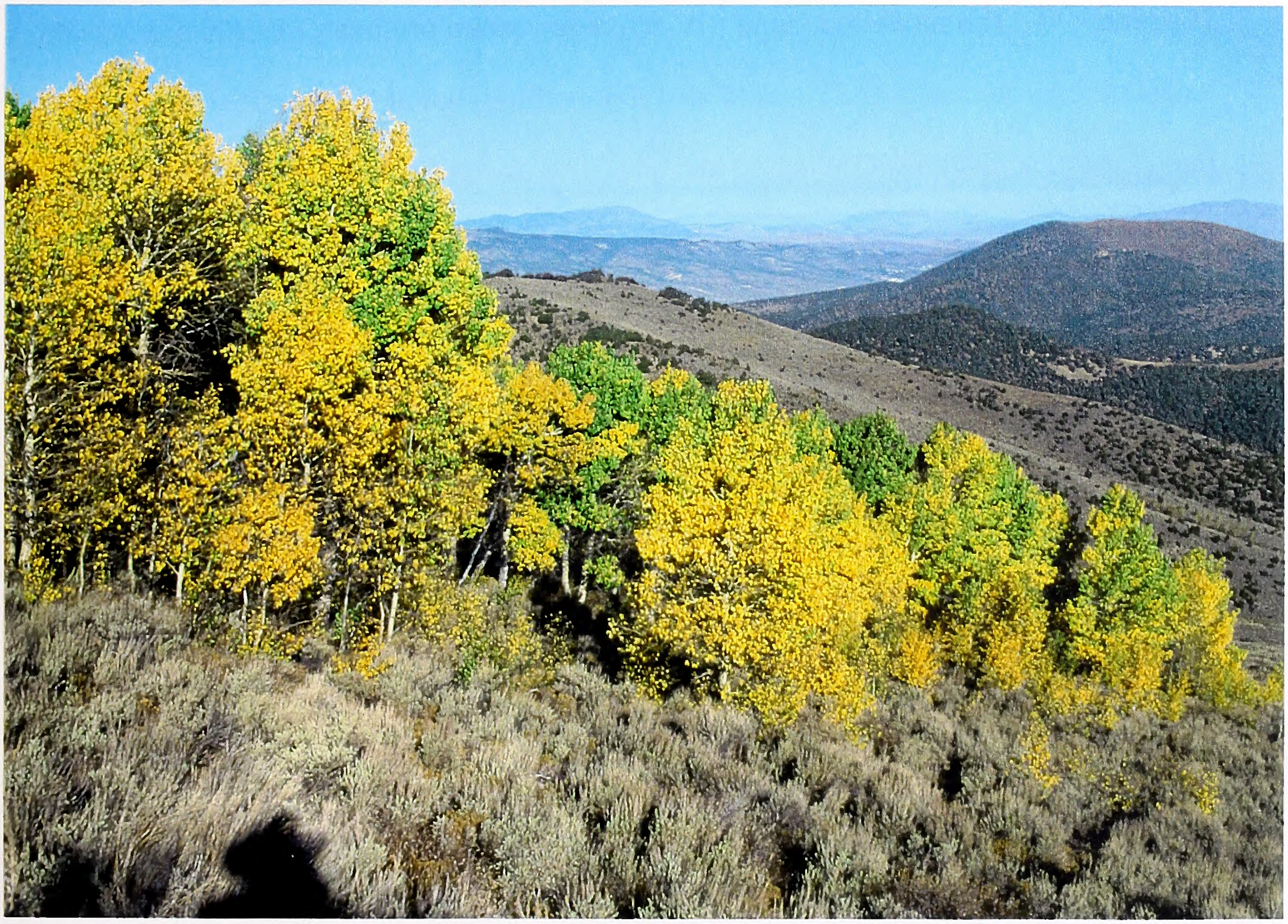

Figure 42. The effect of slope and distance to water on the ability of aspen in the Iowa Creek drainage to successfully produce new stems >2 m tall. This stand (NV-80) is located on a moderate slope (20-30%), but is some distance from water. Thus, over the years, cattle have not used this area as heavily as they have other stands (Holechek 1988), and this aspen clone has continually regenerated until today it is multi-aged (Tables 10 and 11). Print from color slide (Appendix C - - No. 612) by Charles E. Kay; October 4, 2000.

Bernd Canyon

Part of an aspen stand was also fenced to exclude cattle in upper Bernd Canyon (Appendix A). The protected stand (NV-85) regenerated profusely (10,500 saplings/A), while the unprotected (NV-86) stand also regenerated, but at substantially lower stem density (810 saplings/A) (Tables 10 and 11). The exclosure fence was subsequently cut and livestock have had access to the inside plot for the last few years. The regenerated aspen stems have now all been heavily browsed and highlined by cattle (Figure 43). There was very little sign of mule deer in either Bernd Canyon or Boone and Iowa Creeks (Table 10). Mule deer were using the fenced areas along Boone Creek (NV-77), but there was little evidence of browsing on aspen inside the exclosures (Table 10).

Silver Creek

BLM also built an exclosure (BLM 4916) on the upper portion of Silver Creek in 1990 (Appendix A). Unfortunately, that exclosure does not contain aspen. A single aspen clone (NV-87), though, is located above the fenced area. That stand and the surrounding area had been heavily grazed by cattle, and the clone contained only 21 live stems >2 m tall (Figure 44). Moreover, the only stems that recently regenerated had all been protected from browsing either by fallen aspen or dense brush. If this stand is not fenced, it likely will be lost as there are few other places for cattle to shade-up in this part of the canyon. This aspen stand is also immediately adjacent to a spring (Figure 44).

Figure 43. Aspen (NV-85) inside the upper Bernd Canyon Exclosure. Aspen regenerated when this area was fenced to exclude livestock. The fence, however, was subsequently cut and cattle have since heavily browsed and highlined those stems. Print from color slide (Appendix C - - No. 652) by Charles E. Kay; October 4, 2000.

Figure 44. Aspen stand NV-87 in upper Silver Creek. This area was heavily used by cattle and only where protected by fallen trees or dense brush have any aspen stems been able to grow >2 m tall. Note the spring immediately below the stand. Print from color slide (Appendix C - - No. 665) by Charles E. Kay; October 4, 2000.

Desatoya Mountains

Within the Desatoya Mountains (Appendix C - - slides 670-916), aspen was measured in the Campbell Creek (NV-88 to 94), Pole Creek (NV-95 to 99), Milkhouse Creek (NV-100 to 102), Billie Creek (NV-103 to 105), and Smith Creek (NV-106 to 109) drainages (Appendix A). Aspen was also visually evaluated along Edwards Creek where BLM has built a number of exclosures. As with most other areas in central Nevada, BLM does not have any actual, long-term range-use data for specific drainages in the Desatoya Mountains. Billie Creek, Milkhouse Creek, upper Smith Creek, and Pole Creek are in the Porter Canyon Allotment, while Campbell Creek is in the Smith Creek Allotment. The Smith Creek Allotment is administered by the Battle Mountain Field Office, but the Porter Canyon Allotment is administered by BLM's Carson City Office.

Campbell Creek

Within this drainage, aspen is limited to a few stands along the upper reaches of Campbell Creek and three clones along the road between Campbell and Pole Creeks (Appendix A). The lower stands (NV-88 and 89) along Campbell Creek were heavily utilized by cattle and aspen had not regenerated except where individual stems were protected by fallen trees or thick brush (Tables 13 and 14; Figures 45 and 46; Ripple

Table 13. Aspen stand parameters in the Desatoya Mountains.

	Stand Number												
	NV-88	NV-89	NV-90	NV-91	NV-92	NV-93	NV-94	NV-95	NV-96	NV-97	NV-98	NV-99	NV-100
Section	29	29	29	30	20	20	20	19	20	20	20	16	16
Township	17N	17N	17N	17N	17N	17N	17N	17N	17N	17N	17N	17N	17N
Range	38E	38E	38E	38E	38E	38E	38E	38E	38E	38E	38E	38E	38E
UTM	437600E 4351250N	437400E 4351300N	436750E 4351450N	436500E 4351500N	437100E 4352400N	437300E 4352200N	437400E 4352000N	436500E 4353200N	437100E 4353500N	437300E 4353600N	436650E 4352900N	438000E 4354150N	439000E 4355000N
Elevation (ft)	7700	7780	7900	8040	8200	8100	7900	8400	8070	7920	8280	7640	7400
Aspect	NE-E-SE	NE-E-SE	N-NE-E	NE-E-SE	SE	SE	SE	NE-E-SE	NE-E-SE	NE-E-SE	NE	E	N
Slope (%)	5-15	10-15	20-30	30-40	30	30	20	15-30	15-30	15-30	30	10	5
Stand size (m)	40x200	40x200	60x200	80x200	70x200	70x300	30x30	70x100	100x300	100x200	50x70	20x50	60x200
Regeneration highlined (%)	NA	NA	100	50	100	100	100	100	100	100	100	100	100
Suckers browsed(%)	100	100	100	100	100	100	100	100	100	100	100	100	100
Stem densities (A)													
<2 m	810	1485	2295	2092	1148	1012	180	1688	2498	1620	1350	742	472
2m< < 5cm DBH	0	0	945	1282	540	878	76	135	405	202	202	540	270
6-10 cm DBH	0	0	270	270	8572	8842	0	675	338	675	945	675	540
11-20 cm DBH	0	0	0	0	0	0	0	0	0	0	135	0	0
>21 cm DBH	68	68	202	135	0	0	4	135	135	135	68	68	135
Pellet groups*													
Cattle	7	4	2	2	9	8	6	5	7	6	4	2	3
Deer	0	0	0	0	0	0	0	0	0	0	0	0	0
Water**	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes

*Pellet groups per 2x30 m belt transect.
**Water in or near stand.
NA=Not applicable.

Table 13. Aspen stand parameters in the Desatoya Mountains.

	Stand Number								
	NV-101	NV-102	NV-103	NV-104	NV-105	NV-106	NV-107	NV-108	NV-109
Section	9	10	4	4	4	5	5	4	3
Township	17N	17N	17N	17N	17N	17N	17N	17N	17N
Range	38E	38E	38E	38E	38E	38E	38E	38E	38E
UTM	439250E 4355600N	440100E 4355550N	439600E 4358200N	439600E 4358200N	439200E 4352500N	438100E 4357700N	438450E 4357200N	439100E 4357000N	440500E 4356900N
Elevation (ft)	7240	7160	7370	7370	7500	7760	7600	7440	7180
Aspect	E	E	E	E	NE-E-SE	SE	SE	E	SE
Slope (%)	5-10	5-10	5	5	10-15	10	10	10	10
Stand size (m)	60x200	60x200	30x30	15x20	50x300	100x200	60x300	50x300	30x300
Regeneration highlined (%)	20	20	0	NA	NA	100	NA	100	100
Suckers browsed(%)	52	50	0	100	100	100	100	100	100
Stem densities (A)									
<2 m	1418	1080	9788	202	675	1215	945	945	1688
2m< < 5cm DBH	5805	6480	10868	0	0	202	0	5602	3172
6-10 cm DBH	1215	742	0	0	0	135	0	338	202
11-20 cm DBH	0	0	0	0	0	0	0	0	0
>21 cm DBH	202	135	202	68	135	135	135	135	202
Pellet groups*									
Cattle	1	1	0	12	5	5	7	1	2
Deer	0	0	0	0	0	0	0	0	0
Water**	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

*Pellet groups per 2x30 m belt transect.
**Water in or near stand.
NA=Not applicable.

Table 14. Age and diameter of aspen in the Desatoya Mountains.

Stand Number	Stem Diameter (cm)/Age (yrs)
NV-88	56/118, 60/122
NV-89	60/120
NV-90	3/15, 3/15, 4/17, 5/18, 7/22, 7/22, 8/27, 8/25, 34/112, 38/115
NV-91	3/14, 3/16, 5/19, 8/22, 9/25, 36/117, 39/121
NV-92	5/20, 6/20, 7/20, 8/20, 10/20, 10/20, 10/20, 10/20, 10/21
NV-93	5/20, 6/19, 7/19, 8/20, 9/20, 10/20, 10/20
NV-94	38/115
NV-95	4/14, 5/15, 7/15, 8/15, 8/15, 10/18, 36/115, 38/118
NV-96	5/14, 7/15, 8/16, 8/17, 10/18, 11/26, 33/118
NV-97	4/15, 5/14, 8/16, 9/17, 34/117
NV-98	5/15, 6/15, 9/22, 13/28, 15/28, 42/118
NV-99	4/14, 5/15, 7/16, 8/17, 10/20, 36/115
NV-100	5/14, 10/20, 39/117, 42/120, 48/R*
NV-101	2/5, 2/6, 3/8, 3/7, 3/9, 3/14, 4/10, 7/13, 8/16, 14/26, 14/28, 14/30, 39/R*, 42/R*, 46/118
NV-102	2/6, 3/10, 4/11, 7/14, 8/15, 14/30, 14/25, 14/29, 47/118
NV-103	2/4, 2/4, 64/150, 65/R*, 68/R*
NV-104	66/R*, 67/R*
NV-105	8/15, 8/17, 48/140
NV-106	4/13, 5/17, 5/19, 11/17, 12/20, 34/110, 36/115, 53/146, 60/R*, 64/R*
NV-107	47/115
NV-108	3/16, 4/15, 4/15, 5/15, 5/16, 6/18, 6/17, 35/112, 38/115
NV-109	3/12, 3/14, 4/15, 5/15, 6/17, 39/113

*Stem with heart rot that could not be aged.

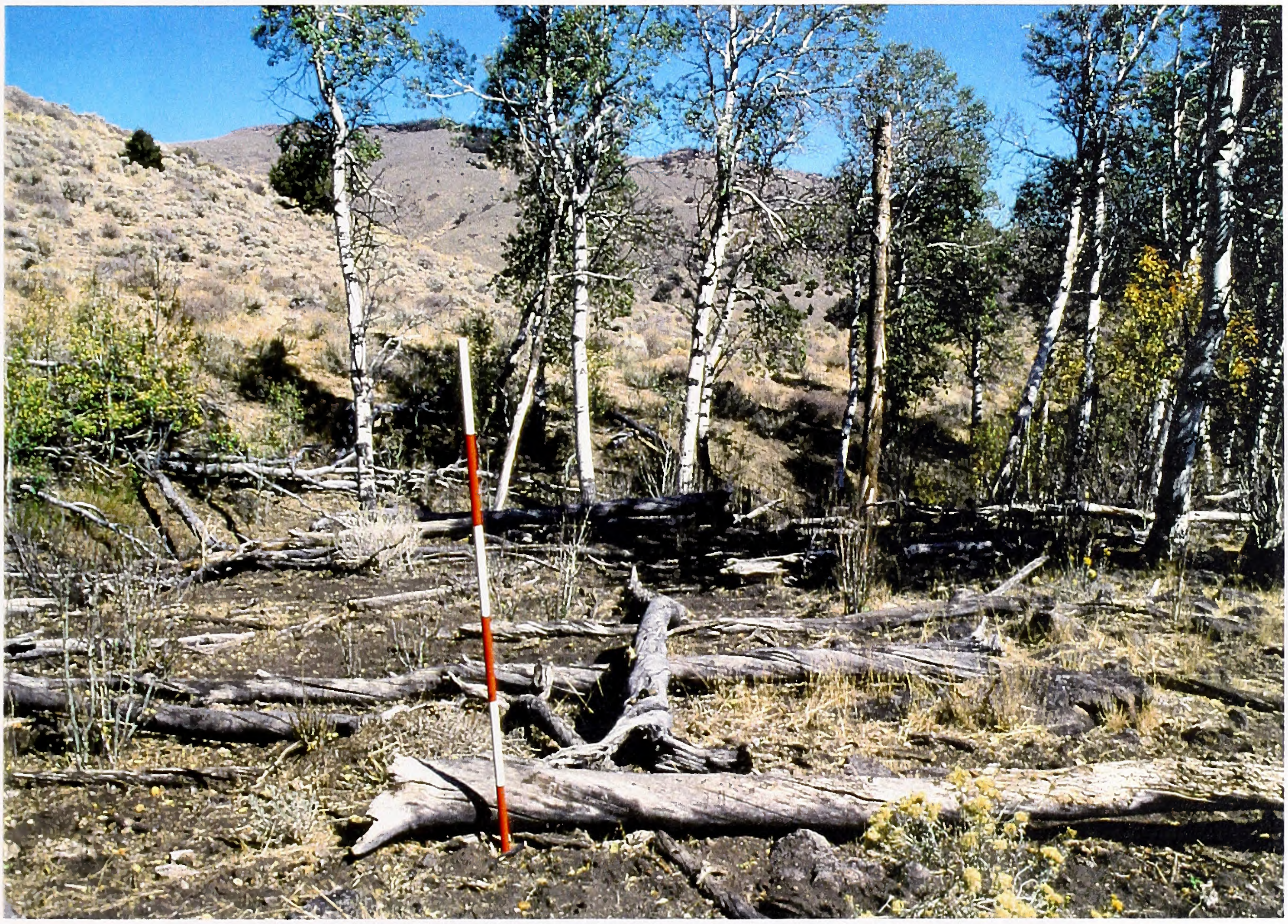

Figure 45. A typical stand (NV-45) at the lower limit of aspen along Campbell Creek. Stands in this area are in decline and have not been able to successfully produce new stems >2 m tall due to repeated herbivory, except where individual stems have been protected from livestock by thick brush (Figure 46) or fallen trees. Aspen in the steeper, upper reaches of Campbell Canyon, however, had successfully regenerated. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 691) by Charles E. Kay; October 5, 2000.

Figure 46. A regenerated aspen stem protected from browsing in the Campbell Creek drainage. Herbivory is so intense that only aspen protected by fallen trees (Ripple and Larsen 2001) or thick brush have been able to grow more than 2 m tall. The shrub is a Ribes sp. (Currant), which generally are not grazed by livestock due to those plants' low palatability and thorns. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 680) by Charles E. Kay; October 5, 2000.

and Larsen 2001). Aspen (NV-90 and 91) in the steeper, upper reaches of Campbell Canyon, however, had successfully produced new stems >2 m tall (Tables 13 and 14).

Two of the three aspen stands along the road to Pole Creek were burned by wildfire 20 years ago, and both clones (NV-92 and 93) regenerated profusely during a period when BLM records indicate the area was not grazed by livestock. Those stands contained more than 9,000 saplings/A, but all the stems had been heavily browsed and highlined by cattle (Figure 47). The single unburned stand in this area (NV-94) was also heavily used by cattle and only a few aspen stems had been able to grow >2 m tall where protected by thick brush.

Pole, Milkhouse, and Smith Creeks

This allotment changed ownership about two decades ago and for several years during that period the range was not fully stocked as one rancher sold-off his cattle while another built-up his herd (Tracey Jean Wolfe, BLM Range Management Specialist, personal communication, Dec. 2000). This allowed some aspen stands (Figures 48 and 49) to regenerate and most likely accounts for the 15-20 year age class seen in those clones (Table 13 and 14). Other stands (Figures 50 and 51) in these drainages, though, have not regenerated in nearly 120 years (Tables 13 and 14). This pattern of regenerated and non-regenerating aspen is related to site-specific use by livestock (Holechek 1988), because aspen stands protected by steep, stream banks or fallen trees had generally regenerated (Figure 49), while stands on gentle slopes with easier access had not (Figure 51).

Figure 47. A fire regenerated aspen stand (NV-92) in upper Campbell Creek. This aspen clone was burned by wildfire 20 years ago and regenerated during a period when livestock numbers were low. Cattle have now heavily browsed and highlined all the new aspen stems. Aspen growth, however, has been excellent. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 708) by Charles E. Kay; October 5, 2000.

Figure 48. Aspen that successfully regenerated along upper Smith Creek. Some aspen stands in the Pole, Milkhouse, and Smith Creek drainages successfully produced new stems >2 m tall when livestock numbers were low 15-20 years ago. Other stands, though, have not regenerated in nearly 120 years - - see Figures 50 and 51. Print from color slide (Appendix C - - No. 843) by Charles E. Kay; October 7, 2000.

Figure 49. Aspen that successfully regenerated along Milkhouse Creek. Aspen in this stand (NV-101) have been protected by fallen trees and steep, stream banks - - Milkhouse Creek is barely visible in the photograph. Other aspen stands in this and adjacent drainages, however, have not regenerated in nearly 120 years (Figures 50 and 51). Print from color slide (Appendix C - - No. 781) by Charles E. Kay; October 6, 2000.

Figure 50. An aspen stand along Pole Creek that has not successfully regenerated in recent years. Note the lack of understory vegetation on the stream banks and the 3 feet of silt trapped behind the rock dam. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 745) by Charles E. Kay; October 6, 2000.

Figure 51. Aspen (NV-106) along upper Smith Creek that failed to regenerate in nearly 120 years except where individual stems had been protected by fallen trees or thick brush. Note the lack of understory vegetation, as well as the heavily grazed riparian area. Print from color slide (Appendix C - - No. 865) by Charles E. Kay; October 7, 2000.

Billie Creek

Aspen (NV-105) in the Billie Creek drainage has generally failed to produce new stems >2 tall in more than 100 years (Tables 13 and 14). Recently, however, a small aspen stand was fenced along Billie Creek. That exclosure was built in 1996 by the previous ranch manager, who thought he was enclosing private property - - there is some private land in this drainage, but the area has never been surveyed and the exact ownership is unknown (Tracey Jean Wolfe, BLM Range Management Specialist, personal communication, Dec. 2000). Although the exclosure was gated, the woven-wire fence was subsequently cut by unknown person or persons. Someone then piled aspen logs in front of that opening to prevent cattle from reaching the inside, fenced area (Figure 52). Why any or all of this was done is not known, at least to BLM. The net result, however, is that there now is a 4 year-old aspen exclosure on Billie Creek - - the stream flows through the fenced area.

Despite the fact that aspen at this site had not regenerated for 150 years, the stand sprouted profusely once livestock use was eliminated (Tables 13 and 14). Within the fenced area (NV-103), there were over 20,000 stems/A and more than half were already >6 ft tall (Figure 53). While on adjacent, outside portions of the clone (NV-104), there were only 202 suckers/A and no stems were more than a foot in height (Figure 54). Understory plants also showed a marked response (Table 15). Inside the exclosure, grass and forb cover increased from 15% to 80%, while bare soil declined from 50% to 5%. Riparian habitat showed similar improvement (Figures 55 and 56).

Table 15. Understory species composition of aspen stands in the Desatoya Mountains. T=trace.

	Stand Number and Percent Canopy Cover												
Species	NV-88	NV-89	NV-90	NV-91	NV-92	NV-93	NV-94	NV-95	NV-96	NV-97	NV-98	NV-99	NV-100
Big sagebrush	25	20	10	10	5	5	20	5	T	T	T	20	5
Rose	5	5	-	-	-	-	10	-	-	-	T	10	10
Rubber rabbitbrush	10	10	T	-	-	-	-	-	T	-	-	T	-
Currant	5	5	T	5	5	5	5	-	T	T	T	5	10
Chokecherry	T	5	-	5	-	-	-	T	T	T	-	-	-
Snowberry	T	T	10	10	5	5	30	5	-	T	-	T	-
Willow	-	T	T	T	-	-	-	-	-	-	-	5	10
Elderberry	-	-	T	-	-	-	-	-	-	-	-	-	-
Green rabbitbrush	-	-	-	-	-	-	-	-	-	-	-	-	-
Juniper	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinyon	-	-	-	-	-	-	-	-	-	-	-	-	-
Grasses	10	10	15	15	10	10	10	10	10	10	10	10	20
Forbs	5	5	15	15	10	10	5	10	15	10	5	10	10
Bare soil	20	15	10	10	20	25	10	50	60	60	60	20	10
Litter	20	20	30	20	30	25	5	10	20	20	20	20	20
Rock	T	T	5	5	T	T	T	5	T	T	T	T	T
Downed aspen	T	T	10	5	15	15	T	5	5	5	5	T	5

Table 15. Understory species composition of aspen stands in the Desatoya Mountains. T=trace.

	Stand Number and Percent Canopy Cover								
Species	NV-101	NV-102	NV-103	NV-104	NV-105	NV-106	NV-107	NV-108	NV-109
Big sagebrush	-	-	T	15	10	15	10	5	10
Rose	30	35	-	-	T	5	5	20	15
Rubber rabbitbrush	-	-	T	5	-	-	-	-	-
Currant	5	T	T	-	T	T	T	T	T
Chokecherry	-	-	-	-	-	-	-	-	-
Snowberry	-	-	-	-	-	-	-	-	-
Willow	T	5	-	-	T	-	-	-	-
Elderberry	-	-	-	-	-	-	-	-	-
Green rabbitbrush	-	-	-	-	T	-	-	-	-
Juniper	-	-	-	-	T	-	T	-	-
Pinyon	-	-	-	-	T	-	-	-	-
Grasses	20	20	60	10	15	20	15	15	15
Forbs	15	10	20	5	5	10	5	10	10
Bare soil	10	T	5	50	35	15	30	20	20
Litter	20	20	10	20	30	20	30	25	25
Rock	T	T	-	-	T	T	T	T	T
Downed aspen	10	10	5	T	5	5	5	5	5

Figure 52. Aspen exclosure on Billie Creek. Despite the gate on the right, the woven wire fence to the left was cut by person or persons unknown. Someone then placed aspen logs in front of the opening to prevent entry by cattle. Note the profusion of aspen suckers inside the exclosure with only 4 years of protection. Print from color slide (Appendix C - - No. 793) by Charles E. Kay; October 7, 2000.

Figure 53. Aspen (NV-103) inside the Billie Creek Exclosure. With 4 years of protection, aspen repsprouted at greater than 20,000 stems/A and more than half those stems were over 6 ft tall. Prior to enclosure, this aspen stand had not regenerated in 150 years. Understory plants also increased in cover, while bare soil declined. Compare this with Figure 54. Print from color slide (Appendix C - - No. 815) by Charles E. Kay; October 7, 2000.

Figure 54. Aspen (NV-104) outside the Billie Creek Exclosure. This site was still heavily used by cattle. Aspen had sprouted profusely inside the exclosure, but not on grazed parts of the same clone. Compare this with Figure 53. Print from color slide (Appendix C - - No. 815) by Charles E. Kay; October 7, 2000.

Figure 55. Riparian conditions inside the Billie Creek Exclosure. This area along Billie Creek had been protected for only 4 years, yet the stream was barely visible - - compare this with Figure 56. Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 807) by Charles E. Kay; October 7, 2000.

Figure 56. Riparian conditions along Billie Creek immediately above the Billie Creek Exclosure. This area is still grazed by cattle - - compare with Figure 55. The tall, grass-like plant along the stream is iris (Iris sp.), which is not grazed by livestock (Dayton 1960:56). Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 823) by Charles E. Kay; October 7, 2000.

Edwards Creek

In recent years, BLM has constructed a series of livestock exclosures along Edwards Creek (Appendix A). Where cattle have been excluded, aspen has regenerated (Figure 57) and riparian conditions have improved (Figure 58).

Figure 57. Aspen regeneration inside a BLM exclosure on Edwards Creek. Where aspen has been protected from livestock, it regenerated without fire or other disturbance. Print from color slide (Appendix C - - No. 898) by Charles E. Kay; October 8, 2000.

Figure 58. Riparian conditions along Edwards Creek where livestock have been excluded. BLM has built a number of exclosures on Edwards Creek in recent years. Compare this with Figure 56. Print from color slide (Appendix C - - No. 912) by Charles E. Kay; October 8, 2000.

Roberts Mountains

Within the Roberts Mountains (Appendix C - - slides 917 to 1038), aspen was measured on Vinini Creek (NV-110 and 114), Willow Creek (NV-111 to 113), Henderson Creek (NV-115 and 116), upper Pete Hanson Creek (NV-119), East Roberts Creek (NV-117 and 118), Roberts Creek (NV-120 to 122), and Cottonwood Creek (NV-123 to 126). All BLM exclosures were also checked for the presence of aspen (Appendix A). This included upper and lower Vinini Creek Exclosures (BLM 4714), the East Roberts Exclosure (BLM 4715), the Willow Creek Meadow Exclosure (BLM 4779), the Roberts Mountain Exclosure (BLM 4439), the three exclosures on Roberts Creek (BLM 4917), Cottonwood Exclosure No. 1 (BLM 4730), Cottonwood Exclosure No. 2 (BLM 4843) - - this included three adjacent fenced plots, and the six exclosures in Meadow Canyon (BLM 4760, 4761, 4777, 4882, and 4884). Only the lower exclosure in Cottonwood Canyon (BLM 4730) contained aspen.

All the exclosures in Meadow Canyon (Appendix A) were functional and none had recently been grazed by livestock. The four exclosures in Cottonwood Canyon, however, had all been heavily grazed by cattle. The perimeter fences were in working order, but apparently the gates had been opened and cattle allowed to graze inside. The exclosure in Willow Creek had also been heavily used by cattle, as that fence was down. The two exclosures on Vinini Creek, though, were still functional and neither had been grazed by livestock. The fence appeared intact at the East Roberts Exclosure, but cattle had heavily grazed the inside area - - again, someone apparently opened the gate. The two lowermost exclosures on Roberts Creek did not appear to have been grazed, but there was some use by domestic sheep inside the two uppermost exclosures (Appendix A). In fact, the lower gate on the uppermost exclosure was open when that site was checked.

Two allotments cover this section of the Roberts Mountains. The Three Bars Allotment includes Meadow, Cottonwood, Pete Hanson, and Willow Creeks, while the Roberts Mountain Allotment includes Vinini and Roberts Creeks. Both allotments are grazed by cattle and domestic sheep. In the last 30 years there have been many changes in the permitted AUM's on each allotment, but BLM does not have actual use data for any of the areas that contain aspen. Total AUM's for both allotments, however, have declined from over 21,000 during the early 1970's to 11,355 today (Joe Ratliff, BLM Soil Scientist, personal communication, Dec. 2000).

Vinini, Henderson, East Roberts, and Pete Hanson Creeks

Aspen in these drainages has not successfully regenerated in many years (Tables 16-17, Figures 59 and 60) except where small groups of stems have been protected by fallen trees, steep stream banks, and/or thick brush (Figure 61). All sites had been heavily grazed by livestock and bare soil was common in most aspen stands (Table 18).

Table 16. Aspen stand parameters in the Roberts Mountains.

	Stand Number												
	NV-110	NV-111	NV-112	NV-113	NV-114	NV-115	NV-116	NV-117	NV-118	NV-119	NV-120	NV-121	NV-122
Section	17	6	6	6	17	29	20	24	24	11	23	23	26
Township	23N	23N	23N	23N	23N	23N	23N	23N	23N	23N	23N	23N	23N
Range	51E	51E	51E	51E	51E	51E	51E	50E	50E	50E	50E	50E	50E
UTM	563150E 4412500N	560800E 4416900N	561300E 4416200N	561500E 4414800N	562000E 4411600N	563150E 4409800N	563850E 4409900N	559500E 4410350N	559300E 4409900N	557050E 4412950N	558150E 4411020N	558350E 4410400N	558750E 4409750N
Elevation (ft)	7560	7400	7520	7880	7960	7740	7460	7700	7520	8400	7840	7740	7500
Aspect	W	NE	N-NW	N-NE	E	NW	E	SE	SE	W	S	SE	S
Slope (%)	10	10	10-20	15	20-30	35	10-30	15	10	10	5	15	40-50
Stand size (m)	20x100	80x200	30x120	50x110	60x100	50x80	20x300	40x150	30x100	20x40	20x30	50x200	50x200
Regeneration highlined (%)	NA	100	100	100	NA	NA	NA	NA	NA	NA	NA	100	0
Suckers browsed(%)	100	100	100	100	100	100	100	100	100	100	100	100	38
Stem densities (A)													
<2 m	608	1080	608	8100	1485	7020	1418	810	945	3240	472	3982	1958
2m< < 5cm DBH	0	135	202	135	0	0	0	0	0	0	0	1755	2970
6-10 cm DBH	0	1890	540	675	0	0	0	0	0	0	0	0	878
11-20 cm DBH	0	0	0	68	68	68	0	0	0	0	135	0	270
>21 cm DBH	68	135	68	202	202	202	135	135	135	135	0	135	202
Pellet groups*													
Cattle	6	5	4	6	***	***	***	***	***	***	***	***	***
Deer	0	0	0	0	***	***	***	***	***	***	***	***	***
Water**	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes

*Pellet groups per 2x30 m belt transect.
**Water in or near stand.
***No data as the ground was covered with snow.
NA=Not applicable.

Table 16. Aspen stand parameters in the Roberts Mountains.

	Stand Number			
	NV-123	NV-124	NV-125	NV-126
Section	6	6	6	6
Township	22N	22N	22N	22N
Range	50E	50E	50E	50E
UTM	552100E 4405800N	552150E 4406100N	551500E 4406300N	551400E 4406250N
Elevation (ft)	7480	7360	7240	7200
Aspect	N	NW	NW	W-NW
Slope (%)	20	10-30	10-15	10-15
Stand size (m)	50x70	30x80	20x80	20x70
Regeneration highlined (%)	NA	NA	NA	NA
Suckers browsed(%)	100	100	100	100
Stem densities (A)				
<2 m	810	1418	405	742
2m< < 5cm DBH	0	0	0	0
6-10 cm DBH	0	0	0	0
11-20 cm DBH	0	0	0	0
>21 cm DBH	135	135	68	68
Pellet groups*				
Cattle	***	***	***	***
Deer	***	***	***	***
Water**	Yes	Yes	Yes	Yes

*Pellet groups per 2x30 m belt transect.
**Water in or near stand.
***No data as the ground was covered with snow.
NA=Not applicable.

Table 17. Age and diameter of aspen in the Roberts Mountains.

Stand Number	Stem Diameter (cm)/Age (yrs)
NV-110	56/60, 6/62
NV-111	3/24, 3/24, 4/25, 4/26, 4/28, 8/32, 9/31, 10/30, 25/95, 27/100
NV-112	4/28, 4/29, 5/28, 5/29, 5/29, 9/30, 10/30, 17/32, 17/34, 38/112
NV-113	4/28, 5/30, 11/32, 17/57, 18/58, 20/60, 34/75, 63/R*, 70/R*
NV-114	16/46, 18/50, 20/58, 28/60, 32/65
NV-115	16/57, 17/58, 32/60, 34/61
NV-116	29/58, 32/60
NV-117	36/74, 39/75
NV-118	37/72, 38/74
NV-119	25/73, 27/75
NV-120	17/55, 18/55
NV-121	4/7, 4/7, 4/23, 5/13, 5/14, 5/12, 5/15, 32/73, 35/75, 38/77
NV-122	2/6, 3/8, 4/7, 6/12, 7/17, 8/14, 10/23, 12/31, 12/38, 14/40, 18/50, 20/52, 32/75, 34/73
NV-123	44/103, 46/105
NV-124	36/102, 38/105
NV-125	34/107
NV-126	35/103

*Stem with heart rot that could not be aged.

Table 18. Understory species composition of aspen stands in the Roberts Mountains. T=trace.

	Stand Number and Percent Canopy Cover												
Species	NV-110	NV-111	NV-112	NV-113	NV-114	NV-115	NV-116	NV-117	NV-118	NV-119	NV-120	NV-121	NV-122
Big sagebrush	20	5	5	5	15	5	10	5	5	5	50	5	5
Snowberry	-	5	5	T	-	5	-	T	-	-	T	-	-
Serviceberry	-	5	-	-	T	-	T	T	-	5	-	-	-
Oregon grape	-	5	-	-	-	-	-	-	-	-	-	-	-
Juniper	-	T	-	-	-	-	-	-	-	-	-	-	-
Chokecherry	-	5	5	T	5	5	5	T	5	20	-	5	20
Currant	-	-	5	T	5	10	5	-	-	-	-	-	5
Willow	-	-	-	5	-	-	10	5	10	-	-	T	10
Rose	-	-	10	-	-	-	10	5	5	-	-	5	15
Elderberry	-	-	-	-	-	-	-	-	-	-	-	-	-
Grasses	25	15	10	10	*	*	*	*	*	*	*	*	*
Forbs	5	5	5	10	*	*	*	*	*	*	*	*	*
Bare soil	20	25	30	40	*	*	*	*	*	*	*	*	*
Litter	30	20	25	30	*	*	*	*	*	*	*	*	*
Rock	T	10	T	T	T	T	T	5	5	20	T	T	10
Downed aspen	T	T	T	T	T	T	5	5	5	T	T	5	10

*No data as ground was snow covered.

Table 18. Understory species composition of aspen stands in the Roberts Mountains. T=trace.

Species	Stand Number and Percent Canopy Cover			
	NV-123	NV-124	NV-125	NV-126
Big sagebrush	-	25	15	15
Snowberry	5	5	10	5
Serviceberry	5	-	-	-
Oregon grape	-	-	-	-
Juniper	-	-	-	-
Chokecherry	10	-	5	-
Currant	5	5	5	5
Willow	20	T	5	5
Rose	10	5	10	5
Elderberry	-	T	-	-
Grasses	*	*	*	*
Forbs	*	*	*	*
Bare soil	*	*	*	*
Litter	*	*	*	*
Rock	T	T	T	T
Downed aspen	5	T	T	T

*No data as ground was snow covered.

Figure 59. A typical aspen stand (NV-110) in Vinini Creek. Aspen stands in most of the Roberts Mountains have failed to regenerate despite excellent height and diameter growth. The trees in this stand were 60 cm DBH, but only 60± years of age. Print from color slide (Appendix C - - No. 923) by Charles E. Kay; October 9, 2000.

Figure 60. A typical aspen stand (NV-117) in East Roberts Creek. Aspen stands in most of the Roberts Mountains have failed to regenerate due to repeated browsing of aspen suckers. Print from color slide (Appendix C - - No. 987) by Charles E. Kay; October 11, 2000.

Figure 61. Aspen regeneration (NV-118) protected by fallen trees and steep cut-banks along East Roberts Creek. Where protected from browsing by fallen trees (Ripple and Larsen 2001) or other natural barriers, aspen has successfully regenerated in the Roberts Mountains. This suggests that repeated use by livestock, not other factors, has been responsible for the general failure of aspen to regenerate. Print from color slide (Appendix C - - No. 993) by Charles E. Kay; October 11, 2000.

Willow Creek

Aspen in Willow Creek also exhibited signs of heavy use by livestock, but unlike most stands in the Roberts Mountains, aspen in this drainage experienced a regeneration event 25-35 years ago (Tables 16 and 17, Figure 62). The reasons for this are not known, but since this and other aspen-containing areas in the Roberts Mountains have not burned, changes in aspen stem dynamics in Willow Creek may be related to past reductions in grazing pressure. That is to say, these aspen stands may have regenerated 25-35 years ago during a time when actual livestock use was low.

Roberts Creek

In Roberts Creek, aspen stands on flat areas near water had not generally regenerated during the last 70 years, while stands on steeper slopes usually had some regeneration (Tables 16 and 17). Much of that regeneration, though, has now been heavily browsed and highlined by domestic sheep (Figure 63). A few clones in very steep areas with many fallen trees, however, showed little sign of ungulate use and aspen stems in those stands were multi-aged, indicative of continual regeneration (Figure 64).

Figure 62. A typical aspen stand (NV-112) in Willow Creek. Unlike most of the Roberts Mountains where aspen has failed to regenerate in many years, aspen in Willow Creek experienced a regeneration event 25-35 years ago. The 4-17 cm DBH stems pictured here were all 24-34 years of age (Table 17). These stands, however, have not been able to produce any younger stems >2 m tall due to repeated browsing by livestock. When measured, these stands were all heavily used by cattle and bare soil was common (Table 18). Red and white survey pole (6 ft) for scale. Print from color slide (Appendix C - - No. 950) by Charles E. Kay; October 9, 2000.

Figure 63. Aspen regeneration (NV-121) along upper Roberts Creek. Aspen in some parts of Roberts Creek regenerated in the recent past, but all those stems have since been heavily browsed and highlined by domestic sheep. Note how sheep have consumed all the lower branches on the young aspen. Print from color slide (Appendix C - - No. 1009) by Charles E. Kay; October 11, 2000.

Figure 64. Aspen regeneration (NV-122) along upper Roberts Creek. Where aspen has been protected by steep banks, fallen trees, or thick brush, grazing pressure has been less, and those stands continually regenerated over many years. Multi-aged stands, however, were not common in the Roberts Mountains because most areas had been subjected to years of heavy utilization by cattle and/or domestic sheep. Print from color slide (Appendix C - - No. 1021) by Charles E. Kay; October 11, 2000.

Cottonwood Creek

Except where protected by fallen trees or steep, stream banks, aspen in the Cottonwood drainage had not regenerated in over 100 years (Tables 16 and 17, Figure 65). This was also true inside the single exclosure (BLM 4730) that contained aspen, because livestock apparently have had repeated access to the inside fenced area, as they did during the 2000 grazing season.

Figure 65. A typical aspen stand (NV-124) in Cottonwood Creek. Aspen in this drainage has generally not regenerated in more than 100 years due to repeated use by livestock. Print from color slide (Appendix C - - No. 1028) by Charles E. Kay; October 12, 2000.

DISCUSSION AND CONCLUSIONS

Aspen in the Shoshone, Simpson Park, Diamond, Toiyab, Desatoya, and Roberts Mountains is generally in poor condition and many stands have not successfully regenerated in 100 years or more. During the present study, no sign of elk was observed in or near any aspen stand, so elk have not contributed to the decline of aspen on BLM lands in central Nevada. In other areas, however, elk have had and are having serious, negative effects on aspen communities (Kay 1985, 1997a, 1997c, 2001a, 2001b; White et al. 1998a, 1998b; Ripple and Larsen 2000; White 2001). If elk colonize the Shoshone, Simpson Park, Diamond, Toiyabe, Desatoya, or Roberts Mountains, or are transplanted into those ranges, it is highly likely that elk would have a negative impact on aspen in those areas.

Forest succession is also not a problem in the aspen stands that were studied, as conifers had not invaded any of the communities that were measured. Aside from Pinyon (Pinus spp.). and Juniper (Juniperus spp.), conifers are generally absent from the mountain ranges that were visited in central Nevada. There is also no evidence that normal plant succession favors sagebrush over aspen, as claimed by some (Schenbeck and Dahlem 1975). Where it has been protected from grazing, aspen in central Nevada has not succeeded to sagebrush, but instead has maintained its position in the vegetation association or actually replaced sagebrush. This has occurred inside all the exclosures that were measured in central Nevada, as well as in Threemile Canyon, where livestock have been absent for many years. Other exclosure studies have found that protected aspen stands have expanded and actually kill-out sagebrush (Kay 1990, 2001b; Kay and Bartos 2000). Thus, there are no data to support the contention that the decline of aspen in central Nevada is due to normal successional processes.

Exclosure studies also suggest that climate has had little impact on aspen in central Nevada (Kay and Bartos 2000, Kay 2001b). Aspen inside the total-exclusion portion of the Bates Mountain exclosures, successfully regenerated without fire or other disturbance, while aspen in adjacent, but unprotected clones, did not. The same was true along Boone and Iowa Creeks, where BLM fenced aspen to exclude livestock. A similar situation exists in Threemile Canyon where all undisturbed aspen stands successfully regenerated and developed multi-aged stands, while aspen in adjacent canyons did not. In fact, data from across in the West has failed to demonstrate a relationship between climatic variation and a corresponding decline in aspen (DeByle and Winohur 1985; Baker et al. 1997; Kay 1997a, 2001a, 2001b; White et al. 1998a, 1998b; Kay and Bartos 2000; White 2001).

It is also commonly believed that aspen has declined due to fire suppression by federal and state land management agencies (Houston 1973, 1982; Despain et al. 1986; Romme et al. 1995). BLM certainly has suppressed fires in central Nevada for many years and none of the areas studied showed any evidence of widespread fire, except for the lower reaches of Homestead and Sheep Canyons. Moreover, of the several hundred aspen stands evaluated during the present study, only a few clones in lower Homestead and Sheep Canyons, and two clones in upper Campbell Creek had burned during the last 20 years. In addition, aspen-age data suggest that few aspen stands in central Nevada have burned during the last 100 years. Thus, from the standpoint of aspen ecology, it may be appropriate to reintroduce fire to non-cheatgrass (Bromus tectorum) infested summer ranges in Nevada. It must be remembered, though, that burned aspen communities will not successfully regenerate if ungulate herbivory is excessive (Bartos and Mueggler 1981, White et al. 1998b, Kay 2001a).

While fire usually has a positive effect on aspen, recall that all the burned aspen stands in Homestead, Sheep, and Campbell Creeks successfully regenerated, the condition and trend of aspen communities in central Nevada are not, in general, related to an absence of fire. If only burned aspen stands were capable of producing new stems greater than 6 ft tall, then aspen inside fenced plots or aspen protected by fallen trees, should not be able to successfully regenerate. In all cases where aspen was protected from ungulate herbivory in central Nevada, however, it successfully regenerated without fire or other disturbance, and the same is true throughout the West (White et al. 1998b, Kay and Bartos 2000, Kay 2000b, White 2001). Thus, while fire can benefit the species, aspen has not declined solely due to fire suppression. This leaves ungulate herbivory as the main reason aspen has declined in central Nevada, and across the West (Kay 1997a, Kay and Bartos 2000, Ripple and Larsen 2000, White 2001).

Data from exclosures on Bates Mountain, Boone Creek, and Iowa Creek indicate that ungulate herbivory has had a major influence on aspen stem dynamics and understory species composition in central Nevada. Most herbivory was attributable to domestic livestock, not wildlife. Of the 819 pellet groups recorded on aspen belt transects during the present study (Tables 4, 7, 10, 13, and 16), 486 (59.3%) were from domestic sheep, 330 (40.2%) from cattle, and 3 (0.4%) from mule deer. In addition, mule deer have access to Threemile, Homestead, and Sheep Canyons in the Diamond Mountains, but only where livestock were absent in Threemile Canyon had all aspen stands successfully regenerated, while aspen in the other canyons was heavily browsed. Similarly, aspen regenerated throughout central Nevada wherever it happened to be protected by the interlocking branches of fallen trees (Ripple and Larsen 2001), by steep cut banks, or dense brush. Aspen also regenerated on central Nevada ranges when livestock numbers were temporarily reduced (Bates Mountain) or where cattle grazing had been changed from season-long use to only early-season use (Boone and Iowa Creeks).

The fact that aspen stands on steeper slopes far from water were generally in better condition than stands on more gentle slopes near water, is also related to livestock grazing patterns. According to other studies (Holechek 1988:11-12), slopes of 11-30% reduce cattle grazing by 30%, while slopes of 31-60% receive 60% less use by cattle than areas with 0-10% slope. On sites with slopes over 60%, cattle use is essentially zero. Similarly, areas 1-2 miles from water receive 50% less use by cattle than sites closer to water, while areas more than two miles from water are seldom used by cattle (Holechek 1988:11-12).

I have now personally measured or otherwise evaluated more than 40 aspen exclosures in the western U.S. and Canada (Kay 1990, 2001b; Kay and Bartos 2000), and in all cases where aspen has been protected, it successfully regenerated and formed multi-aged stands without fire or other disturbance. The single, stem-aged stands seen in central Nevada and found throughout the West are not a biological attribute of aspen, but a result of excessive ungulate herbivory. In other areas I have worked, the problem has been too many elk (Kay 1997a, 1997c, 2001a, 2001b; White et al. 1998b) or too many deer (Kay and Bartos 2000). In central Nevada, however, domestic livestock are the predominate ungulate herbivore.

MANAGEMENT RECOMMENDATIONS

To reverse the decline of aspen on BLM administered lands in central Nevada it will be necessary to more closely manage livestock use. Depending on site-specific conditions, it may be necessary to fence some aspen stands if those clones are to survive. In other areas, season of use changes may be sufficient to restore aspen. Year-long or season-long grazing is particularly detrimental to aspen, while early-season or dormant-season use may allow aspen to successfully regenerate. That is to say, the timing of grazing can be more important than the intensity (Borman et al. 1999). As many aspen stands in central Nevada are located in riparian settings, it may also be necessary to fence those areas to exclude livestock and to pipe water to sites some distance from aspen - - of all the springs, seeps, and other water sources observed in central Nevada, few were developed and most were heavily grazed by livestock. AUM reductions may also be necessary on some allotments. In evaluating which measures to implement on what stands, distance to or from water, and the degree of slope are the two most important risk factors (Holechek 1988). Aspen near water is at greater risk than more distant stands and aspen on gentle topography is more at risk than stands on steep slopes - - all other factors being equal.

It is also strongly recommended that BLM establish permanent vegetation sampling plots in aspen communities throughout central Nevada to evaluate any management changes the agency might make. One of the most cost effective ways would be to establish a series of permanent photopoints (Magill 1989, Hart and Laycock

1996).

If fire is used to restore aspen communities, it may be necessary to rest those areas for 1 to 2 years prior to treatment to allow fine fuels to accumulate (Brown and Simmerman 1986). Pure aspen stands are very difficult to burn and will usually burn only early in the spring prior to leaf-out or late in the fall after leaf-drop (Brown and Simmerman 1986). If aspen is burned, it will also be necessary to rest those areas for 3 to 5 years to allow the new suckers to grow beyond the reach of grazing animals. In some cases, this could be accomplished with temporary electric fencing. Whatever is done, however, BLM needs to be more vigilant in its monitoring. All fenced areas and exclosures should be checked yearly to insure that management goals are being met. If fences are cut, BLM may need to take appropriate enforcement actions. BLM may also wish to reconsider its policy of putting gates in some exclosures to prevent those areas from being used as livestock holding pastures.

Shoshone Mountains

Of all the areas evaluated during the present study, aspen in Cottonwood Basin was in the worst condition. Since aspen occupies a relative small portion of this allotment and is so limited in extent, it is recommended that all aspen stands be immediately fenced to exclude livestock. It may also be necessary to fence all the riparian areas, as they too are in exceedingly poor condition. If this is done, water will have to be piped to locations outside the fenced areas. Permanent photopoints should be established in all aspen stands and inside/outside all fenced areas.

Simpson Park Mountains

Insure that the season of use changes made by BLM are implemented on Bates Mountain. Rebuild the total-exclusion part of the Bates Mountain exclosure. Fence high-risk aspen stands. Fence upper-elevation springs and pipe water to upland sites. Establish permanent photopoints to monitor the condition and trend of aspen.

Diamond Mountains

Implement season of use changes in Sawmill, Cottonwood, and Hildebrand drainages. Fence high-risk aspen stands. Fence springs and pipe water to upland sites. Establish permanent photopoints to monitor aspen. Fence all high-risk aspen stands in Sheep and Homestead Canyons - - this would include fencing springs and piping water to upland sites. Establish permanent photopoints to monitor aspen. Threemile Canyon may be the only area in central Nevada that has not been heavily used by livestock for many years (Beever and Brussard 2000:238), and as such, is an exceedingly valuable range reference area. BLM should insure that this area is not grazed by livestock or wild horses in the future. Establish permanent vegetation monitoring plots, including photopoints. It will be interesting to see what impact mule deer have on the vegetation as deer populations increase from present lows.

Toiyabe Mountains

Maintain the season of use changes that were implemented by BLM in 1990, as aspen has responded positively. Maintain the three exclosures on Boone Creek and the three exclosures on Iowa Creek. Insure that the exclosures on Iowa Creek are not used as holding pastures for cattle. Rebuild the exclosure in upper Bernd Canyon. Fence the high-risk aspen stand in Silver Creek. Establish permanent photopoints in all drainages to monitor aspen.

Desatoya Mountains

Fence all aspen stands in upper Campbell Creek - - this would include several springs. Pipe water to upland sites and establish permanent photopoints to monitor aspen. In Pole, Milkhouse, Billie, and Smith Creeks, implement season of use changes to reduce grazing pressure on aspen. Fence high-risk aspen communities. Maintain and monitor the aspen exclosure in Billie Canyon. Establish permanent photopoints in all drainages. Maintain and monitor the exclosures on Edwards Creek.

Roberts Mountains

Maintain all existing exclosures and insure that they are not used as holding pastures for livestock. Repair the single aspen-containing exclosure (BLM 4730) and establish permanent photopoints. Fence all high-risk aspen stands and implement season of use changes to reduce livestock use on aspen. Establish permanent aspen monitoring plots, including photopoints.

LITERATURE CITED

Baker, F.S. 1918. Aspen reproduction in relation to management. Journal of Forestry 16:389-398.

Baker, F.S. 1925. Aspen in the central Rocky Mountain region. U.S. Department of Agriculture Bulletin No. 1291. 47 pp.

Baker, W.L., J. A. Monroe, and A.E. Hessl. 1997. The effects of elk on aspen in the winter range in Rocky Mountain National Park. Ecography 20:155-165.

Balda, R.P. 1975. Vegetation structure and breeding bird diversity. Pages 59-80 in Smith, D.R., ed. Symposium on management of forest and range habitats for nongame birds. U.S. Forest Service General Technical Report WO-1.

Bartos, D.L, and R.B. Campbell, Jr. 1998. Decline of quaking aspen in the interior west - - examples from Utah. Rangelands 20:17-24.

Bartos, D.L., and W.F. Mueggler. 1979. Influence of fire on vegetation production in the aspen ecosystem in western Wyoming. Pages 75-78 in Boyce, M.S. and L.D. Hayden-Wing, eds. North American elk: Ecology, behavior and management. University of Wyoming, Laramie, WY. 294 pp.

Bartos, D.L., and W.F. Mueggler. 1981. Early succession in aspen communities following fires in western Wyoming. Journal of Range Management 34:315-318.

Bartos, D.L., J.K. Brown, and G.D. Booth. 1994. Twelve years biomass response in aspen communities following fire. Journal of Range Management 47:79-83.

Bartos, D.L., W.F. Mueggler, and R.B. Campbell Jr. 1991. Regeneration of aspen by suckering on burned sites in western Wyoming. U.S. Forest Service Research Paper INT-448. 10 pp.

Beever, E.A., and P.F. Brussard. 2000. Examining ecological consequences of feral horse grazing using exclosures. Western North American Naturalist 60:236-254.

Borman, M.M., C.R. Massingill, and E.W. Elmore. 1999. Riparian area responses to changes in management. Rangelands 21:3-7.

Brown, J.K., and D.G. Simmerman. 1986. Appraisal of fuels and flammability in western aspen: A prescribed fire guide. U.S. Forest Service General Technical Report INT-205. 48 pp.

Cartwright, C.W., Jr., and D.P. Burns. 1994. Sustaining our aspen heritage into the twenty-first century. U.S. Forest Service, Southwestern Region. 6 pp.

Casey, D., and D. Hein. 1983. Effects of heavy browsing on a bird community in deciduous forest. Journal of Wildlife Management 47:829-836.

Clary, W.P., and W.C. Leininger. 2000. Stubble height as a tool for management of riparian areas. Journal of Range Management 53:562-573.

Coles, F.H. 1965. The effects of big game and cattle grazing on aspen regeneration. M.S. Thesis, Brigham Young University, Provo, UT. 72 pp.

Daily, G.C., P.R. Ehrlich, and N.M. Haddad. 1993. Double keystone bird in a keystone species complex. Proceedings of the National Academy of Science 90:592-594.

Davis, J.N., and J.D. Brotherson. 1991. Ecological relationships of curlleaf mountain-mahogany (Cercocarpus ledifolius nutt) communities in Utah and implications for management. Great Basin Naturalist 51:153-166.

Dayton, W.A. 1960. Notes on western range forbs: Equisetaceae through Fumariaceae. U.S. Forest Service, Washington, D.C. 254 pp.

DeByle, N.V., C.D. Bevins, and W.C. Fisher. 1987. Wildfire occurrence in aspen in the interior western United States. Western Journal of Applied Forestry 2:73-76.

DeByle, N.V., and R.P. Winokur, eds. 1985. Aspen: Ecology and management in the western United States. U.S. Forest Service General Technical Report RM-119. 283 pp.

Despain, D., D. Houston, M. Meagher, and P. Schullery. 1986. Wildlife in transition: Man and nature on Yellowstone's northern range. Roberts Rinehart, Boulder, CO. 142 pp.

Dobel, M. 1999. Estimating Nevada's deer herds. Nevada Wildlife Almanac (Fall-Winter):6.

Ehrlich, P.R., and G.C. Daily. 1993. Birding for fun: Sapsuckers, swallows, aspen, and rot. American Birds 47(1):18-20.

Endersby, H. 1999. The aspen-mule deer link. Mule Deer 4(2):16-19.

Fechner, G.H., and J.S. Barrows. 1976. Aspen stands as wildfire fuelbreaks. Eisenhower Consortium Bulletin 4:1-26. U.S. Forest Service rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Finch, D.M., and L.F. Ruggiero. 1993. Wildlife habitats and biological diversity in the Rocky Mountains and northern Great Plains. Natural Areas Journal 13:191-203.

Flack, J.A.D. 1976. Bird populations of aspen forests in western North America. Ornithological Monograph No. 19. 97 pp.

Grant, M.C. 1993. The trembling giant. Discover 14(10):82-89.

Grant, T.A., and G.B. Berkey. 1999. Forest area and avian diversity in fragmented aspen woodland of North Dakota. Wildlife Society Bulletin 27:904-914.

Gruell, G.E., and L.L. Loope. 1974. Relationships among aspen, fire and ungulate browsing in Jackson Hole, Wyoming. U.S. Forest Service Intermountain Region, Ogden, UT. 33 pp.

Hart, R.H., and W.A. Laycock. 1996. Repeat photography on range and forest lands in the western United States. Journal of Range Management 49:60-67.

Holechek, J.L. 1988. An approach for setting the stocking rate. Rangelands 10:10-14.

Houston, D.B. 1973. Wild fires in northern Yellowstone National Park. Ecology 54:1111-1117.

Houston, D.B. 1982. The northern Yellowstone elk: Ecology and management. MacMillan Publishers, New York, NY. 474 pp.

Jelinski, D.E., and W.M. Cheliak. 1992. Genetic diversity and spatial subdivision of Populus tremuloides (Salicaceae) in a heterogenous landscape. American Journal of Botany 79:728-736.

Johns, B.W. 1993. The influence of grove size on bird species richness in aspen parklands. Wilson Bulletin 105:256-264.

Johnson, M.A. 1994. Changes in southwestern forests: Stewardship implications. Journal of Forestry 92(12):16-19.

Kay, C.E. 1985. Aspen reproduction in the Yellowstone Park-Jackson Hole area and its relationship to the natural regulation of ungulates. Pages 131-160 in

Workman, G.W., ed. Western elk management: A symposium. Utah State University, Logan, UT. 213 pp.

Kay, C.E. 1990. Yellowstone's northern elk herd: A critical evaluation of the "natural regulation" paradigm. Ph.D. Dissertation, Utah State University, Logan, UT. 490 pp.

Kay, C.E. 1993. Aspen seedlings in recently burned areas in Grand Teton and Yellowstone National Parks. Northwest Science 67:94-104.

Kay, C.E. 1997a. Is aspen doomed? Journal of Forestry 95(5):4-11.

Kay, C.E. 1997b. Aspen: A new perspective - - implications for park management and ecological integrity. Pages 265-273 in Harmon, D., ed. Marking protection work: Proceedings of the 9th conference on research and resource management in parks and on public lands. The George Wright Society, Hancock, MI. 493 pp.

Kay, C.E. 1997c. The condition and trend of aspen, Populus tremuloides, in Kootenay and Yoho National Parks: Implications for ecological integrity. Canadian Field-Naturalist 111:607-616.

Kay, C.E. 2000. Native burning in western North America: Implications for hardwood management. Pages 19-27 in Yaussy, D.A., ed. Proceedings: Workshop on fire, people, and the central hardwood landscape. U.S. Forest Service General Technical Report NE-274. 129 pp.

Kay, C.E. 2001a. Evaluation of burned aspen communities in Jackson Hole, Wyoming. In sustaining aspen in western landscapes. U.S. Forest Service General Technical Report RM-xxx. In press.

Kay, C.E. 2001b. Long-term aspen exclosures in the Yellowstone ecosystem. In sustaining aspen in western landscapes. U.S. Forest Service General Technical Report RM-xxx. In press.

Kay, C.E., C.A. White, I.R. Pengelly, and B. Patton. 1999. Long-term ecosystem states and processes in Banff National Park and the central Canadian Rockies. Parks Canada Occasional Paper No. 9, Environment Canada, Ottawa, ON.

Kay, C.E., and D.L. Bartos. 2000. Ungulate herbivory on Utah aspen: Assessment of long-term exclosures. Journal of Range Management 53:145-153.

Kay, C.E., and F.H. Wagner. 1994. Historic condition of woody vegetation on Yellowstone's northern range: A critical test of the "natural regulation" paradigm. Pages 151-169 in Despain, D.G., ed. Plants and their environments' - - Proceeding of the first biennial scientific conference on the Greater Yellowstone Ecosystem. U.S. National Park Service, Denver, CO. Technical Report NPS/NRYELL/NRTR-93/XX. 347 pp.

Kay, C.E., and F.H. Wagner. 1996. The response of shrub-aspen to Yellowstone's 1988 wildfires: Implications for "natural regulation" management. Pages 107-111 in Greenlee, J.M., ed. Ecological implications of fire in Greater Yellowstone: Proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, WA. 235 pp.

Kennedy, T.B., A.M. Merenlender, and G.L. Vinyard. 2000. A comparison of riparian condition and aquatic invertebrate community indices in central Nevada. Western North American Naturalist 60:255-272.

Krebill, R.G. 1972. Mortality of aspen on the Gros Ventre elk winter range. U.S. Forest Service Research Paper INT-129. 16 pp.

Laycock, W.A. 1975. Rangeland reference areas. Society for Range management, Range Science Series No. 3. 34 pp.

Loope, L.L., and G.E. Gruell. 1973. The ecological role of fire in the Jackson Hole area, northwestern Wyoming. Quaternary Research 3:425-443.

McDonough, W.T. 1979. Quaking aspen seed germination and early seedling growth. U.S. Forest Service Research Paper INT-234. 13 pp.

McDonough, W.T. 1985. Sexual reproduction, seeds and seedlings. Pages 25-28 in N.V. DeByle, and R.P. Winokur, eds. Aspen: Ecology and management in the western United States. U.S. Forest Service General Technical Report RM-119. 283 pp.

Magill, A.W. 1989. Monitoring environmental change with color slides. U.S. Forest Service General Technical Report PSW-117. 55 pp.

Mitton, J.B. and M.C. Grant. 1996. Genetic variation and the natural history of quaking aspen. Bioscience 46:25-31.

Mueggler, W.F. 1988. Aspen community types of the Intermountain region. U.S. Forest Service General Technical Report INT-250. 135 pp.

Mueggler, W.F. 1989a. Age distribution and reproduction of Intermountain aspen stands. Western Journal of applied Forestry 4:41-45.

Mueggler, W.F. 1989b. Status of aspen woodlands in the West. Pages 32-37 in Pendleton, B.G., ed. Western raptor management symposium and workshop.

National Wildlife Federation Scientific and Technical Series No. 12. Washington, D.C.

Nelson, J.R., and T.A. Leege. 1982. Nutritional requirements and food habits. Pages 323-367 in Thomas, J.S., and D.E. Toweill, eds. Elk of North America: Ecology and management. Stackpole Books, Harrisburg, PA. 698 pp.

Oakleaf, R.F., C. Masser, and T. Nappe. 1983. Livestock and nongame wildlife. Pages 95-102 in Menke, J.W., ed. Proceedings of the workshop on livestock and wildlife-fisheries relationships in the Great Basin. University of California Special Publications 3301. 173 pp.

Olmsted, C.E. 1977. The effect of large herbivores on aspen in Rocky Mountain National Park. Ph.D. Dissertation, University of Colorado, Boulder, CO. 136 pp.

Olmsted, C.E. 1979. The ecology of aspen with reference to utilization by large herbivores in Rocky Mountain National Park. Pages 89-97 in Boyce, M.S., and L.D. Hayden-Wing, eds. North American elk: Ecology, behavior, and management. University of Wyoming, Laramie, WY. 294 pp.

Olmsted, C.E. 1997. Twenty years of change in Rocky Mountain National Park winter range aspen. Technical Report. Environmental Studies Program, University of Northern Colorado, Greeley, CO. 41 pp.

Page, J.L., N. Dodd, T.O. Osborne, and J.A. Carson. 1978. The influence of livestock grazing on non-game wildlife. California-Nevada Wildlife 1978:159-173.

Perala, D.A. 1990. Quaking aspen. Pages 555-569 in Burns, R.M., and B.H. Honkala, eds. Silvics of north America. Volume 2. hardwoods. U.S. Department of

Agriculture, Agriculture Handbook 654.

Peterson, E.B., and N.M. Peterson. 1992. Ecology, management and use of aspen and balsam poplar in the prairie provinces, Canada. Forestry Canada Northern Forest Center Special Report 1. 252 pp.

Peterson, E.B., and N.M. Peterson. 1995. Aspen managers' handbook for British Columbia. British Columbia Ministry of Forests and Canadian Forest Service. FRDA Report 230. 110 pp.

Putman, R.J., P.J. Edwards, J.C.E. Mann, R.C. How, and S.D. Hill. 1989. Vegetational and faunal changes in an area of heavily grazed woodland following relief of grazing. Biological Conservation 47:13-32.

Ripple, W.J., and E.J. Larsen. 2000. Historic aspen recruitment, elk, and wolves in northern Yellowstone National Park, USA. Biological Conservation 95:361-370.

Ripple, W.J., and E.J. Larsen. 2001. The role of postfire coarse woody debris in aspen regeneration. Western Journal of Applied Forestry 16:In press.

Romme, W.H., M.G. Turner, L.L. Wallace, and J.S. Walker. 1995. Aspen, elk, and fire in northern Yellowstone National Park. Ecology 76:2097-2106.

Sampson, A.W. 1919. Effect of grazing upon aspen reproduction. U.S. Department of Agriculture Bulletin No. 741. 29 pp.

Schenbeck, G.L., and E.A. Dahlem. 1977. Proposed management of aspen habitat in northern Nevada. California-Nevada Wildlife 1977:68-74.

Schier, G.A. 1975. Deterioration of aspen clones in the middle Rocky Mountains. U.S. Forest Service Research Paper INT-170. 14 pp.

Schier, G.A., and R.B. Campbell. 1980. Variation among healthy and deteriorating aspen clones. U.S. Forest Service Research Paper INT-264. 12 pp.

Schultz, B.W., P.T. Tueller, and R.J. Tausch. 1990. Ecology of curlleaf mahogany in western and central Nevada: Community and population structure. Journal of Range Management 43:13-20.

Schultz, B.W., R.J. Tausch, and P.T. Tueller. 1991. Size, age, and density relationships in curlleaf mahogany (Cercocarpus ledifolius) populations in western and central Nevada: Competitive implications. Great Basin Naturalist 51:183-191.

Shepperd, W.D. 1993. Initial growth, development, and clonal dynamics of regenerated aspen in the Rocky Mountains. U.S. Forest Service Research Paper RM-312. 8 pp.

Shepperd W.D., and F.W. Smith. 1993. The role of near-surface lateral roots in the life cycle of aspen in the central Rocky Mountains. Forest Ecology and Management 61:157-170.

Shepperd, W.D., and M.L. Fairweather. 1994. Impact of large ungulates in restoration of aspen communities in a southwestern ponderosa pine ecosystem. Pages 344-347 in Covington, W.S., and L.F. DeBano, eds. Sustainable ecological systems: Implementing an ecological approach to land management. U.S. Forest Service General Technical Report RM-247. 363 pp.

Stelfox, J.B., ed. 1995. Relationship between stand age, stand structure, and biodiversity in aspen mixedwood forests in Alberta. Jointly published by Alberta

Environmental Centre, Vegreville, AB and Canadian Forest Service, Edmonton, AB. 308 pp.

Taylor, D.M. 1986. Effects of cattle grazing on passerine birds nesting in riparian habitat. Journal of Range Management 39:254-258.

Tueller, P.T. 1979. Food habits and nutrition of mule deer on Nevada ranges. Nevada Department of Fish and Game and Nevada Agricultural Experiment Station, Final Report, Federal Aid in Wildlife Restoration, Project W-48-5, Study 1, Job 2. 104 pp.

Tueller, P.T., and L.A. Monroe. 1980. Management guidelines for selected deer habitats in Nevada. University of Nevada Agricultural Experiment Station Publication No. R-104. 185 pp.

U.S. Forest Service. 1993. Changing conditions in southwestern forests and implications on land stewardship. U.S. Forest Service, Southwest Region. 8 pp.

Wallmo, O.C., and W.L. Regelin. 1981. Rocky mountain and intermountain habitats. Part 1. Food habits and nutrition. Pages 387-38 in Wallmo, O.C., ed. Mule and black-tailed deer of North America. University of Nebraska Press, Lincoln, NE. 605 pp.

Weatherill, R.G., and L.B. Keith. 1969. The effect of livestock grazing on an aspen forest community. Alberta Department of Lands and Forests, Fish and Wildlife Division Technical Bulletin No. 1. 31 pp.

Weinstein, J. 1979. The condition and trend of aspen along Pacific Creek in Grand Teton National Park. Pages 78-82 in Boyce, M.S., and L.D. Hayden-wing, eds.

North American elk: Ecology, behavior and management. University of Wyoming, Laramie, WY. 294 pp.

West, N.E., K. McDaniel, E.L. Smith, P.T. Tueller, and S. Leonard. 1994. Monitoring and interpreting ecological integrity on arid and semi-arid lands of the western United States. New Mexico Range Improvement Task Force, Las Cruces, NM. Report 37. 15 pp.

Westworth, D.A., and E.S. Telfer. 1993. Summer and winter bird populations associated with five age-classes of aspen forest in Alberta. Canadian Journal of Forest Research 23:1830-1836.

White, C.A. 2001. Aspen, elk, and fire in the Canadian Rocky Mountains. Ph.D. Dissertation, University of British Columbia, Vancouver, BC. 192 pp.

White, C.A., C.E. Kay, and M.C. Feller. 1998a. Aspen forest communities: A key indicator of ecological integrity in the Rocky Mountains. Pages 506-517 in Munro, N.W.P., and J.H.M. Wilison, eds. Linking protected areas with working landscapes conserving biodiversity. Science and Management of Protected Areas Association. Wolfville, NS.

White, C.A., C.E. Olmsted, and C.E. Kay. 1998b. Aspen, elk, and fire in the Rocky Mountain national parks of North America. Wildlife Society Bulletin 26:449-462.

Winternitz, B.L. 1980. Birds in aspen. Pages 247-257 in Degraff, R.M., ed. Workshop proceedings on management of western forests and grasslands for nongame birds. U.S. Forest Service General Technical Report INT-86.

Young, J.L. 1973. Breeding bird populations and habitat utilization in aspen stands of upper Logan Canyon. M.S. Thesis, Utah State University, Logan, UT. 38 pp.

Young, J.L. 1977. Density and diversity responses of summer bird populations to the structure of aspen and spruce-fir communities on the Wasatch Plateau, Utah. Ph.D. Dissertation, Utah State University, Logan, UT. 79 pp.